Texas A&M Transportation Institute
PROVING GROUND

Test Report No. 690900-PVL5-7

MASH TL-3 EVALUATION OF PROVELI BREAKAWAY POLE SYSTEM

Sponsored by
Proveli

TEXAS A&M TRANSPORTATION INSTITUTE PROVING GROUND
Roadside Safety & Physical Security
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16. Abstract

The purpose of the tests reported herein was to assess the performance of the Proveli Breakaway Pole System according to the safety-performance evaluation guidelines included in the second edition of the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) (*1*). The crash tests were performed in accordance with *MASH* Test Level 3 (TL-3):

1. ***MASH* Test 3-60:** An 1100C vehicle weighing 2420 lb impacting the Support Structures while travelling at 19 mi/h and 0 degrees.
2. ***MASH* Test 3-61:** A 1100C vehicle weighing 2420 lb impacting the Support Structures while traveling at 62 mi/h and 0 degrees.
3. ***MASH* Test 3-62:** A 2270P vehicle weighing 5000 lb impacting the Support Structures while traveling at 62 mi/h and 0 degrees.

This report provides details on the Proveli Breakaway Pole System, the crash tests and results, and the performance assessment of the Proveli Breakaway Pole System for *MASH* TL-3 Support Structures evaluation criteria.

The Proveli Breakaway Pole System met the performance criteria for *MASH* TL-3 Support Structures.

17. Key Words	18. Distribution Statement
Support Structure, Pole, Breakaway, Crash Test, MASH, Occupant Risk, Penetration	Copyrighted. Not to be copied or reprinted without consent from Proveli.

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MASH TL-3 Evaluation of Proveli Breakaway Pole System

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Contract No.: 2404645

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December 2024

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The results reported herein apply only to the article tested. The full-scale crash tests were performed according to TTI Proving Ground quality procedures and American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware, Second Edition (*MASH*) guidelines and standards.

The Proving Ground Laboratory within TTI's Roadside Safety and Physical Security Division ("TTI Lab") strives for accuracy and completeness in its crash test reports. On rare occasions, unintentional or inadvertent clerical errors, technical errors, omissions, oversights, or misunderstandings (collectively referred to as "errors") may occur and may not be identified for corrective action prior to the final report being published and issued. If, and when, the TTI Lab discovers an error in a published and issued final report, the TTI Lab will promptly disclose such error to Proveli, and both parties shall endeavor in good faith to resolve this situation. The TTI Lab will be responsible for correcting the error that occurred in the report, which may be in the form of errata, amendment, replacement sections, or up to and including full reissuance of the report. The cost of correcting an error in the report shall be borne by the TTI Lab. Any such errors or inadvertent delays that occur in connection with the performance of the related testing contract will not constitute a breach of the testing contract.

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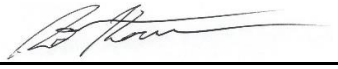

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in^2

*SI is the symbol for the International System of Units

CHAPTER 1.

INTRODUCTION

The purpose of the tests reported herein was to assess the performance of the Proveli Breakaway Pole System according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*), Second Edition (*1*). The crash tests were performed in accordance with *MASH* Test Level 3 (TL-3), which requires three crash tests (as discussed in Chapter 3).

CHAPTER 2.

SYSTEM DETAILS

2.1. TEST ARTICLE AND INSTALLATION DETAILS

The test installation consisted of a Flock Safety solar panel and camera mounted on a multi-part Proveli breakaway pole, with the center of the solar panel at approximately 12 feet 10 inches above grade, and the camera 6 inches below it on the impact side. Three batteries were attached to the bottom of the solar panel. The post was connected to a base section with a break-away connection at 3 inches above grade. The base section was encased in a 12-inch diameter 30-inch-deep un-reinforced concrete foundation.

Figure 2.1 presents the overall information on the Proveli Breakaway Pole System, and Figure 2.2 thru Figure 2.7 provide photographs of the installation. Appendix A provides further details on the Proveli Breakaway Pole System. Drawings were provided by Proveli and the Texas A&M Transportation Institute (TTI) Proving Ground, and assembly and construction was performed by TTI Proving Ground personnel.

2.2. DESIGN MODIFICATIONS DURING TESTS

No modifications were made to the installation during the testing phase.

DESIGN NOTES

1. POLE AND FOUNDATIONS ARE DESIGNED IN ACCORDANCE WITH THE FOLLOWING CODES:
   - 1.1. 2021 INTERNATIONAL BUILDING CODE
   - 1.2. AASHTO LRFD SPECIFICATIONSFOR STRUCTURAL SUPPORT FOR HIGHWAY SIGNS, LUMIN, TRAFFIC SIGNALS, 2015 EDITION.
2. POLE ANALYSIS AND FOUNDATION DESIGN ARE BASED ON THE FOLLOWING CRITERIA
   - 2.1. DESIGN WIND SPEED (Vult)): (SEE SECTION 2.6)
   - 2.2. RISK CATEGORY: II
   - 2.3. EXPOSURE CATEGORY: C
   - 2.4. TOPOGRAPHIC CATEGORY: 1
   - 2.5. SEISMIC DESIGN CRITERIA:
     - 2.5.1. SOIL SITE CLASS: D (ASSUMED)
     - 2.5.2. SPECTRAL RESPONSE, Ss: 1.000g (MAXIMUM)
     - 2.5.3. SPECTRAL RESPONSE, S1: 0.400G (MAXIMUM)
     - 2.5.4. SEISMIC DESIGN CATEGORY: B
   - 2.6. STRUCTURE BASE REACTIONS ARE CALCULATED AS FOLLOWS:

DESIGN WIND SPEED (MPH)	MOMENT (K-FT)	SHEAR (KIP)	AXIAL (KIP)
115	2.70	0.280	0.160
125	3.20	0.330	0.160
135 (MAX.)	3.70	0.380	0.160

   - 2.7. SHOULD ANY OF THE SITE-SPECIFIC PARAMETERS BE HIGHER THAN WHAT IS NOTED ABOVE, THE EOR SHALL BE CONTACTED TO PROVIDE A REVISED DESIGN.
3. CONTRACTOR IS RESPONSIBLE FOR VERIFYING SOIL CONDITIONS PRIOR TO INSTALLATION.
4. FOUNDATION TO CONSIST OF CONCRETE SURROUNDING THE PROPSED POLE WITH A MINMUM OF 3,000-PSI COMPRESSIVE STRENGTH.

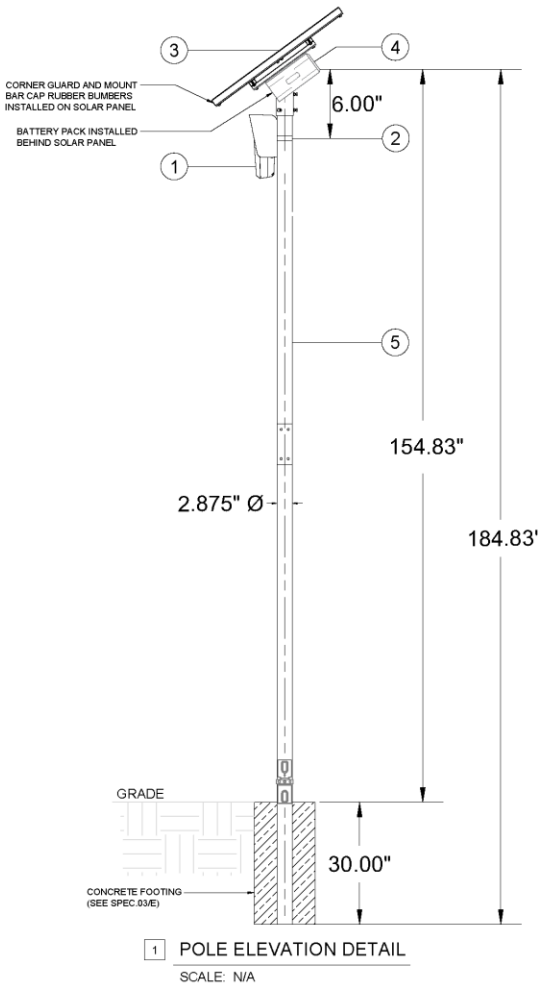
GENERAL & CONSTRUCTION NOTES

1. CONTRACTOR SHALL CONTACT DESIGNATED AGENCY TO LOCATE ALL UNDERGROUND UTILITIES PRIOR TO CONSTRUCTION.
2. CONTRACTOR SHALL APPLY AND OBTAIN AN APPROVED TRAFFIC CONTROL PLAN IN ACCORDANCE WITH MUTCD AND LOCAL JURISDICTION STANDARDS.
3. CONTRACTOR SHALL RESTORE ALL DISTURBED AREAS TO ORIGINAL SITE CONDITION TO THE SATISFACTION OF STATE DEPARTMENT OF TRANSPORTATION AND LOCAL JURISDICTION.
4. ALL WORK SHALL CONFORM TO APPLICABLE ELECTRICAL CODES EXCEPT WHEN STATE DEPARTMENT OF TRANSPORTATION OR LOCAL JURISDICTION STANDARDS SUPERSEDE.
5. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH SPECIFICATIONS DEFINED BY THE STATE DEPARTMENT OF TRANSPORTATION OR LOCAL JURISDICTION, UNLESS SPECIFICALLY STATED OR SHOWN OTHERWISE HEREIN.

ADA COMPLIANCE NOTES

1. ALL SIDEWALK CONSTRUCTION SHALL BE IN ACCORDANCE WITH ADA TITLE II, STATE DEPARTMENT OF TRANSPORTATION, AND LOCAL JURISDICTION STANDARDS,
2. STATE DEPARTMENT OF TRANSPORTATION CURRENT EDITION STANDARDS SHALL BE USED FOR PEDESTRIAN CONTROL PLANS WHEN CLOSURE OF SIDEWALK IS REQUIRED FOR CONSTRUCTION.
3. MINIMUM CLEAR PEDESTRIAN ACCESS ROUTE (PAR) SHALL BE 48" WIDE.
4. NO OBSTRUCTION IS PERMITTED ALONG THE WIDTH OF THE SIDEWALK. UP TO AN ELEVATION OD 7'-0" ABOVE GRADE.

ITEM NO.	PART NUMBER	DESCRIPTION	TOTAL WEIGHT (LB)	QTY.
1	701-0059	FLOCK SAFETY CAMERA	3.6	1
2	201-00097	MOUNTING CLAMP	2.0	1
3	702-00080	65W SOLAR KIT	18.0	1
4	702-00026 / 701-00111	BATTERY PACK	4.0 (APPROX)	3 (MAX)
5	1020-01	PROVELI BREAKAWAY STYLE 7 COUPLER ASSEMBLY	229.39	1



1 POLE ELEVATION DETAIL

SCALE: N/A

flock safety

1170 HOWELL MILL ROAD SUITE 210
ATLANTA, GA 30318

REV	DATE	BY	DESCRIPTION
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
0	09/05/2024	JMW	TYP DETAIL

LICENSE PLATE READER CAMERA INSTALLATION

SHEET:	REV:
SPEC.01	0

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF FLOCK SAFETY. ANY REPRODUCTION IN PART OR IN WHOLE WITHOUT THE WRITTEN PERMISSION OF FLOCK SAFETY IS PROHIBITED. DO NOT SCALE DRAWINGS.

Figure 2.1. Details of Proveli Breakaway Pole System.

Figure 2.2. Proveli Breakaway Pole System prior to Testing.

Figure 2.3. Lower Portion of the Proveli Breakaway Pole System prior to Testing.

Figure 2.4. Base of the Proveli Breakaway Pole System prior to Testing.

Figure 2.5. Joint of the Upper and Lower Portions of the Proveli Breakaway Pole System prior to Testing.

Figure 2.6. Proveli Breakaway Pole and Flock Safety Solar Panel and Camera prior to Testing.

Figure 2.7. Rear of the Proveli Breakaway Pole and Flock Safety Solar Panel prior to Testing.

2.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Breakaway Pole System. Table 2.1 shows the average compressive strengths of the concrete on the day of the test 9/27/2024.

Table 2.1. Concrete Strength.

Location	Design Strength	Avg. Strength	Age
Footers	3000	3460	37

CHAPTER 3.

TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1. CRASH TEST PERFORMED/MATRIX

Table 3.1 shows the test conditions and evaluation criteria for *MASH* TL-3 for Support Structures.

Table 3.1. Test Conditions and Evaluation Criteria Specified for *MASH* TL-3 Support Structures.

Test Designation	Test Vehicle	Impact Speed	Impact Angle	Evaluation Criteria
3-60	1100C	19 mi/h	0º	B, D, F, H, I, N
3-61	1100C	62 mi/h	0º	B, D, F, H, I, N
3-62	2270P	62 mi/h	0º	B, D, F, H, I, N

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 4 presents brief descriptions of these procedures.

3.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-5 and 5-1 of *MASH* were used to evaluate the crash tests reported herein. Table 3.1 lists the test conditions and evaluation criteria required for *MASH* TL-3, and Table 3.2 provides detailed information on the evaluation criteria.

Table 3.2. Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	Evaluation Criteria
B.	The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.
D.	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.
I.	The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.
N.	Vehicle trajectory behind the test article is acceptable.

CHAPTER 4.

TEST CONDITIONS

4.1. TEST FACILITY

The full-scale crash tests reported herein were performed at the TTI Proving Ground, an International Standards Organization (ISO)/International Electrotechnical Commission (IEC) 17025-accredited laboratory with American Association for Laboratory Accreditation (A2LA) Mechanical Testing Certificate 2821.01. The full-scale crash tests were performed according to TTI Proving Ground quality procedures, as well as *MASH* guidelines and standards.

The test facilities of the TTI Proving Ground are located on The Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 mi northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, highway pavement durability and efficacy, and roadside safety hardware and perimeter protective device evaluation. The sites selected for construction and testing are along the edge of an out-of-service apron/runway. The apron/runway consists of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement but are otherwise flat and level.

4.2. VEHICLE TOW AND GUIDANCE SYSTEM

For the testing utilizing the 1100C and 2270P vehicles, each was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

4.3. DATA ACQUISITION SYSTEMS

4.3.1. Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed for crash test service. The data acquisition hardware and software conform to the *MASH* recommended version of SAE J211, Instrumentation for Impact Test. Each of the channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the DAS unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

Each DAS is returned to the factory annually for complete recalibration and to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCOÒ 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a calibration traceable to the International System of Units (SI). Measurement Uncertainties have been determined for critical parameters involved in this testing, and are available upon request by the Sponsor.

TRAP uses the DAS-captured data to compute the occupant to vehicle contact impact velocities, time of occupant to vehicle contact after vehicle impact, and highest 10-millisecond (ms) average ridedown acceleration. TRAP calculates change in vehicle velocity at the end of a given impulse period. In addition, maximum average accelerations over 50-ms intervals in each of the three directions are computed. For reporting purposes, the data from the vehicle-mounted accelerometers are filtered with an SAE Class 180-Hz low-pass digital filter, and acceleration versus time curves for the longitudinal, lateral, and vertical directions are plotted using TRAP.

TRAP uses the data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.0001-s intervals, and then plots yaw, pitch, and roll versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation being initial impact. Measurement Uncertainties

have been determined for critical parameters involved in this testing, and are available upon request by the Sponsor.

4.3.2. Anthropomorphic Dummy Instrumentation

An Alderson Research Laboratories Hybrid II, 50th percentile male anthropomorphic dummy, restrained with lap and shoulder belts, was placed in the front seat on the right side of the 1100C vehicle. The dummy was not instrumented.

According to *MASH*, use of a dummy in the 2270P vehicle is optional, and no dummy was used in the test.

4.3.3. Photographic Instrumentation Data Processing

Photographic coverage of each test included 2 digital high-speed cameras:

- One placed with a field of view perpendicular to the impact path and in-line with the point of impact
- One placed downstream from the impact point at an oblique angle to the impact path

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the Breakaway Pole System. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of each test vehicle and the installation before and after the test.

CHAPTER 5.

MASH TEST 3-60 (CRASH TEST 690900-PVL-5)

5.1. CRITICAL IMPACT POINT LOCATION

The Critical Impact Point (CIP) for this test was centerline of the vehicle aligned 13 inches off the centerline of the installation towards the left side. The target CIP for this test was determined using the information provided in *MASH* Section 2.2.4.1. Figure 5.1 shows the target CIP for test 690900-PVL-5. Figure 5.2 and Figure 5.3 depict the vehicle at the CIP prior to test 690900-PVL-5.

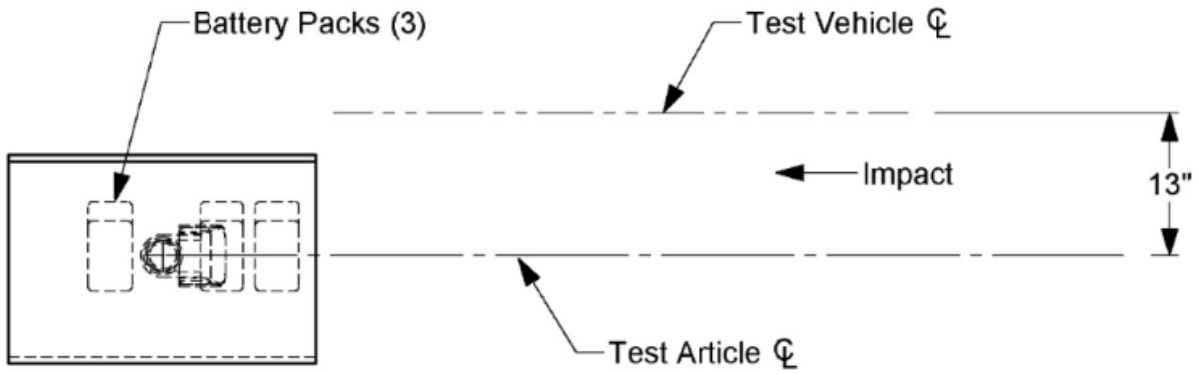


Figure 5.1. Target CIP for *MASH* Test 3-60 on Proveli Breakaway Pole System.

Figure 5.2. Proveli Breakaway Pole System/Test Vehicle Geometrics for Test 690900-PVL-5.

Figure 5.3. Proveli Breakaway Pole System/Test Vehicle Impact Location for Test 690900-PVL-5.

5.2. TEST VEHICLE DETAILS PRIOR TO IMPACT

Table 5.1 shows the vehicle measurements. Figure 5.4 and Figure 5.5 show the 2019 Nissan Versa used for the crash test. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Table 5.1. Vehicle Measurements for Test 690900-PVL-5.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2416 lb
Gross Static[a] Mass	2585 lb	±55 lb	2581 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	41.1 inches
CG above Ground[c,d]	N/A	N/A	N/A

Note: N/A = not applicable; CG = center of gravity.

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.

[b] Average of front and rear axles.

[c] For test inertial mass.

[d] 2270P vehicle must meet minimum CG height requirement.

Figure 5.4. Front of Test Vehicle before Test 690900-PVL-5.

Figure 5.5. Rear of Test Vehicle before Test 690900-PVL-5.

5.3. TEST DESCRIPTION

5.3.1. Weather Conditions

Table 5.2 provides the weather conditions for test 690900-PVL-5.

Table 5.2. Weather Conditions for Test 690900-PVL-5.

Date of Test	9/27/2024
Wind Speed	9 mi/h
Wind Direction	324°
Temperature	83°F
Relative Humidity	51 %
Vehicle Traveling	170°

5.3.2. Test Events

Table 5.3 lists events that occurred during Test 690900-PVL-5. Figures C.4, C.5, and C.6 in Appendix C.2 present sequential photographs during the test.

Table 5.3. Events during Test 690900-PVL-5.

Time	Events
0.0000 s	Vehicle impacted the installation
0.0240 s	Pole began to move
0.0340 s	Pole began to release from base
0.0560 s	Pole released from base

5.4. TEST ACTUAL IMPACT CONDITIONS

Table 5.4 lists the details of the *MASH* impact conditions for this test and Table 5.5 lists the exit parameters.

Table 5.4. Impact Conditions for *MASH Test 3-60,* Crash Test 690900-PVL-5.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	19 mi/h	±2.5 mi/h	18.8 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	34 kip-ft	≤34 kip-ft	28.8 kip-ft
Impact Location	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the drivers side	±6 inches	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the drivers side side

Table 5.5. Exit Parameters for *MASH Test 3-60,* Crash Test 690900-PVL-5.

Exit Parameter	Measured
Speed	14.5 mi/h
Brakes applied post impact	4.5 seconds
Vehicle at rest position	106 ft downstream of impact point In line with the impact path
Comments:	Vehicle remained upright and stable.

5.5. DAMAGE TO TEST INSTALLATION

The base of the footer was sheared off at grade and did not release from the support pole. The support pole and solar panel came to rest 40 feet downstream and 7 feet to the left of the original location of the installation. The solar panel detached from the pole but remained tethered to the camera, which remained intact. The upper section of the support pole was deformed, and there was a slight gap between the upper and lower support pole sections. Figure 5.6 and Figure 5.7 show the damage to the Proveli Breakaway Pole System.

Figure 5.6. Proveli Breakaway Pole System Base at Impact Location after Test 690900-PVL-5.

Figure 5.7. Proveli Breakaway Pole System after Test 690900-PVL-5.

5.6. DAMAGE TO TEST VEHICLE

Figure 5.8 and Figure 5.9 show the damage sustained by the vehicle. Figure 5.10 and Figure 5.11 show the interior of the test vehicle. Table 5.6 and Table 5.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

Figure 5.8. Front of Test Vehicle after Test 690900-PVL-5.

Figure 5.9. Rear of Test Vehicle after Test 690900-PVL-5.

Figure 5.10. Overall Interior of Test Vehicle after Test 690900-PVL-5.

Figure 5.11. Windshield of Test Vehicle after Test 690900-PVL-5.

Table 5.6. Occupant Compartment Deformation for Test 690900-PVL-5.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 lateral inches	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 5.7. Exterior Vehicle Damage for Test 690900-PVL-5.

Test Parameter	Details
Side Windows	Side windows remained intact
Maximum Exterior Deformation	No exterior deformation
VDS	12FC1
CDC	12FCEN1
Fuel Tank Damage	None
Description of Damage to Vehicle:	There was a hairline fracture on the front bumper. Due to this minimal damage, this test vehicle was reused for test 690900-PVL-6.

5.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 5.8. Figure C.7 in Appendix C.3 shows the vehicle angular displacements, and Figures C.8 through C.10 in Appendix C.4 show acceleration versus time traces.

Table 5.8. Occupant Risk Factors for Test 690900-PVL-5.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	5 ft/s	0.4483 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	1.5 ft/s	0.4483 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	0.4 g	3.0773 - 3.0873 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.5 g	2.8401 - 2.8501 seconds
Theoretical Head Impact Velocity (THIV)	N/A	1.6 m/s	0.4488 seconds on front of interior
Acceleration Severity Index	N/A	0.2	0.0286 - 0.0786 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-2.3 g	0.0096 - 0.0596 seconds
50-ms MA Lateral	N/A	-0.4 g	0.2149 - 0.2649 seconds
50-ms MA Vertical	N/A	1.2 g	0.0977 - 0.1477 seconds
Roll	≤75°	16.8°	3.9999 seconds
Pitch	≤75°	2.7°	2.8261 seconds
Yaw	N/A	1.7°	0.2824 seconds

[a.] *Values in italics are the preferred MASH values*

5.8. TEST SUMMARY

Figure 5.12 summarizes the results of *MASH* Test 690900-PVL-5.

0.000 s

0.3000 s

0.6000 s

0.9000s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-60
Project No.:	690900-PVL-5
Test Date:	9/27/2024
TEST ARTICLE	
Type:	Support Structures
Name:	Proveli Breakaway Pole System
Length:	154-8 inches
Key Materials:	28-inch × 21.3-inch solar panel, camera, 2-inch SCH 40 Galvanized Steel Pipe, 2.87500 × 0.203 wall Aluminum pipe
Soil Type and Condition:	Concrete Footer
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2019 Nissan Versa
Inertial Mass:	2416 lb
Dummy Mass:	165 lb
Gross Static Mass:	2581 lb
IMPACT CONDITIONS	
Impact Speed:	18.8 mi/h
Impact Angle:	0°
Impact Location:	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the drivers side
Kinetic Energy:	28.8 kip-ft

EXIT CONDITIONS	
Exit Speed:	14.5 mi/h
Stopping Distance:	106 ft downstream In line
VEHICLE DAMAGE	
VDS:	12FC1
CDC:	12FCEN1
Max Exterior Deformation:	No exterior deformation
Max Occupant Compartment Deformation:	No occupant compartment deformation
OCCUPANT RISK VALUES	
Longitudinal OIV:	5 ft/s
Lateral OIV:	1.5 ft/s
Longitudinal Ridedown:	0.4 g
Lateral Ridedown:	0.5 g
THIV:	1.6 m/s
ASI:	0.2
Max 50ms Longitudinal:	-2.3 g
Max 50ms Lateral:	-0.4 g
Max 50ms Vertical:	1.2 g
Max Roll:	16.8°
Max Pitch:	2.7°
Max Yaw:	1.7°

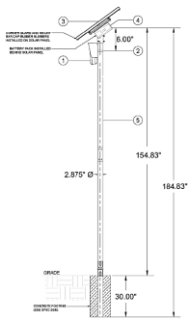


Figure 5.12. Summary of Results for MASH Test 3-60 on Provli Breakaway Pole System.

CHAPTER 6.

MASH TEST 3-61 (CRASH TEST 690900-PVL-6)

6.1. CRITICAL IMPACT POINT LOCATION

The Critical Impact Point (CIP) for this test was centerline of the vehicle aligned 13 inches off the centerline of the installation towards the left side. The target CIP for this test was determined using the information provided in *MASH* Section 2.2.4.1. Figure 6.1 shows the target CIP for test 690900-PVL-6. Figure 6.2 and Figure 6.3 depict the vehicle at the CIP prior to test 690900-PVL-6.

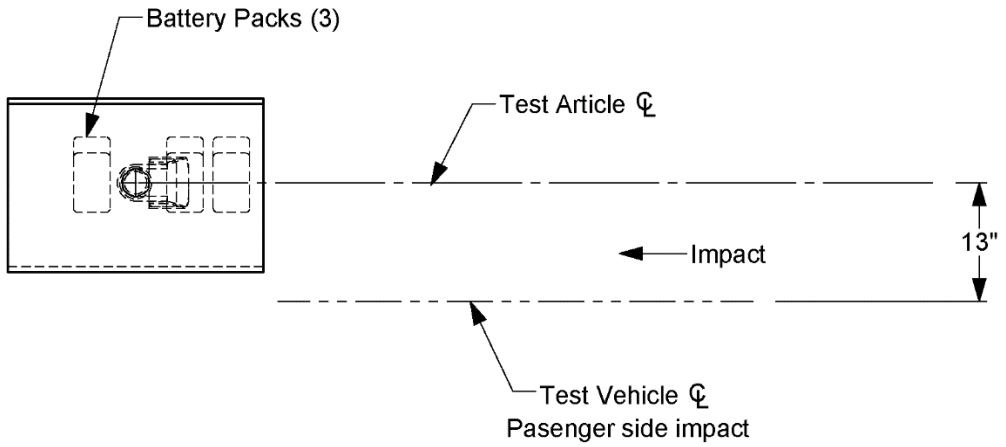


Figure 6.1. Target CIP for *MASH* Test 3-61 on Proveli Breakaway Pole System.

Figure 6.2. Proveli Breakaway Pole System/Test Vehicle Geometrics for Test 690900-PVL-6.

Figure 6.3. Proveli Breakaway Pole System/Test Vehicle Impact Location for Test 690900-PVL-6.

6.2. TEST VEHICLE DETAILS PRIOR TO IMPACT

Table 6.1 shows the vehicle measurements. Figure 6.4 and Figure 6.5 show the 2019 Nissan Versa used for the crash test. Due to the minimal damage caused by test 690900-PVL-5, the same vehicle was used for this test. Figure D.1 in Appendix D.1 gives additional dimensions and information on the vehicle.

Table 6.1. Vehicle Measurements for Test 690900-PVL-6.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2416 lb
Gross Static[a] Mass	2585 lb	±55 lb	2581 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	41.1 inches
CG above Ground[c,d]	N/A	N/A	N/A

Note: N/A = not applicable; CG = center of gravity.

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.

[b] Average of front and rear axles.

[c] For test inertial mass.

[d] 2270P vehicle must meet minimum CG height requirement.

Figure 6.4. Front of Test Vehicle before Test 690900-PVL-6.

Figure 6.5. Rear of Test Vehicle before Test 690900-PVL-6.

6.3. TEST DESCRIPTION

6.3.1. Weather Conditions

Table 6.2 provides the weather conditions for test 690900-PVL-6.

Table 6.2. Weather Conditions for Test 690900-PVL-6.

Date of Test	9/27/2024
Wind Speed	8 mi/h
Wind Direction	334°
Temperature	89 °F
Relative Humidity	42 %
Vehicle Traveling	170°

6.3.2. Test Events

Table 6.3 lists events that occurred during Test 690900-PVL-6. Figures D.4, D.5, and D.6 in Appendix D.2 present sequential photographs during the test.

Table 6.3. Events during Test 690900-PVL-6.

Time	Events
0.0000 s	Vehicle impacted the installation
0.0010 s	Pole began to move
0.0018 s	Pole began to release from base
0.0021 s	Pole released from base
0.2310 s	Top bracing on pole support impacted rear spoiler

6.4. TEST ACTUAL IMPACT CONDITIONS

Table 6.4 lists the details of the *MASH* impact conditions for this test and Table 6.5 lists the exit parameters.

Table 6.4. Impact Conditions for *MASH Test 3-61,* Crash Test 690900-PVL-6.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	62.3 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	288 kip-ft	≥288 kip-ft	316.7 kip-ft
Impact Location	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the passenger side	±6 inches	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the passenger side

Table 6.5. Exit Parameters for *MASH Test 3-61,* Crash Test 690900-PVL-6.

Exit Parameter	Measured
Speed	60.3 mi/h
Brakes applied post impact	2.0 seconds
Vehicle at rest position	345 ft downstream of impact point 12 ft to the right
Comments:	Vehicle remained upright and stable.

6.5. DAMAGE TO TEST INSTALLATION

The base of the footer was deformed, and the lower portion of the support pole sheared. The support pole came to rest 60 feet downstream and 6 feet to the left of the original location of the installation. The lower portion of the support pole was deformed one foot from its base. The solar panel and camera both released from the support pole. Figure 6.6 and Figure 6.7 show the damage to the Proveli Breakaway Pole System.

Figure 6.6. Proveli Breakaway Pole System Base at Impact Location after Test 690900-PVL-6.

Figure 6.7. Proveli Breakaway Pole System after Test 690900-PVL-6.

6.6. DAMAGE TO TEST VEHICLE

Figure 6.8 and Figure 6.9 show the damage sustained by the vehicle. Figure 6.10 and Figure 6.11 show the interior of the test vehicle. Table 6.6 and Table 6.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures D.2 and D.3 in Appendix D.1 provide exterior crush and occupant compartment measurements.

Figure 6.8. Impact Side of Test Vehicle after Test 690900-PVL-6.

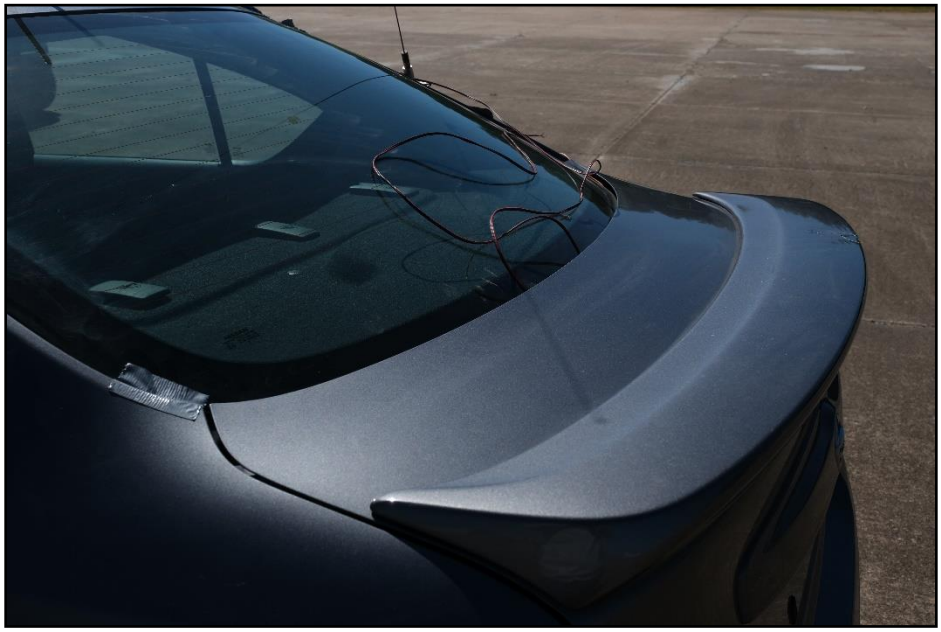


Figure 6.9. Rear of Test Vehicle after Test 690900-PVL-6.

Figure 6.10. Overall Interior of Test Vehicle after Test 690900-PVL-6.

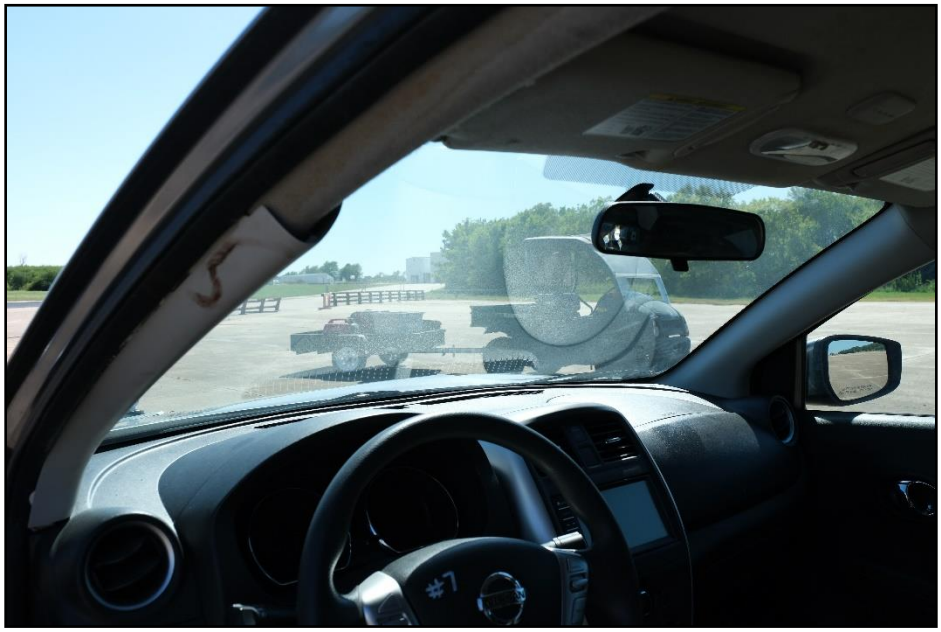


Figure 6.11. Windshield after Test 690900-PVL-6.

Table 6.6. Occupant Compartment Deformation for Test 690900-PVL-6.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 lateral inches	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 6.7. Exterior Vehicle Damage for Test 690900-PVL-6.

Test Parameter	Details
Side Windows	Side windows remained intact
Maximum Exterior Deformation	10 inches in the front plane at bumper height
VDS	12FC2
CDC	12FCEN1
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, grill, hood, radiator, and support were deformed, and the rear spoiler was fractured on the right side

6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.8. Figure D.7 in Appendix D.3 shows the vehicle angular displacements, and Figures D.8 through D.10 in Appendix D.4 show acceleration versus time traces.

Table 6.8. Occupant Risk Factors for Test 690900-PVL-6.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	4.8 ft/s	0.4965 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	3.2 ft/s	0.4965 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	0.5 g	0.7243 - 0.7343 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.7 g	1.2059 - 1.2159 seconds
Theoretical Head Impact Velocity (THIV)	N/A	1.8 m/s	0.5027 seconds on front of interior
Acceleration Severity Index	N/A	0.2	0.0252 - 0.0752 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-2.5 g	0.0005 - 0.0505 seconds
50-ms MA Lateral	N/A	1.5 g	0.0204 - 0.0704 seconds
50-ms MA Vertical	N/A	2.7 g	0.0417 - 0.0917 seconds
Roll	≤75°	3.2°	1.2721 seconds
Pitch	≤75°	2.7°	1.6861 seconds
Yaw	N/A	4.6°	0.5426 seconds

[a.] *Values in italics are the preferred MASH values*

6.8. TEST SUMMARY

Figure 6.12 summarizes the results of *MASH* Test 690900-PVL-6.

0.000 s

0.1000 s

0.2000 s

0.3000s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-61
Project No.:	690900-PVL-6
Test Date:	9/27/2024

TEST ARTICLE	
Type:	Support Structures
Name:	Proveli Breakaway Pole System
Length:	154-8 inches
Key Materials:	28-inch × 21.3-inch solar panel, camera, 2-inch SCH 40 Galvanized Steel Pipe, 2.87500 × 0.203 wall Aluminum pipe
Soil Type and Condition:	Concrete Footer

TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2019 Nissan Versa
Inertial Mass:	2416 lb
Dummy Mass:	165 lb
Gross Static Mass:	2581 lb

IMPACT CONDITIONS	
Impact Speed:	62.3 mi/h
Impact Angle:	0°
Impact Location:	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the passenger side
Kinetic Energy:	316.7 kip-ft

EXIT CONDITIONS	
Exit Speed:	60.3 mi/h
Stopping Distance:	345 ft downstream 12 ft to the right side

VEHICLE DAMAGE	
VDS:	12FC2
CDC:	12FCEN1
Max Exterior Deformation:	10 inches in the front plane at bumper height
Max Occupant Compartment Deformation:	No occupant compartment deformation

OCCUPANT RISK VALUES	
Longitudinal OIV:	4.8 ft/s
Lateral OIV:	3.2 ft/s
Longitudinal Ridedown:	0.5 g
Lateral Ridedown:	0.7 g
THIV:	1.8 m/s
ASI:	0.2
Max 50ms Longitudinal:	-2.5 g
Max 50ms Lateral:	1.5 g
Max 50ms Vertical:	2.7 g
Max Roll:	3.2°
Max Pitch:	2.7°
Max Yaw:	4.6°

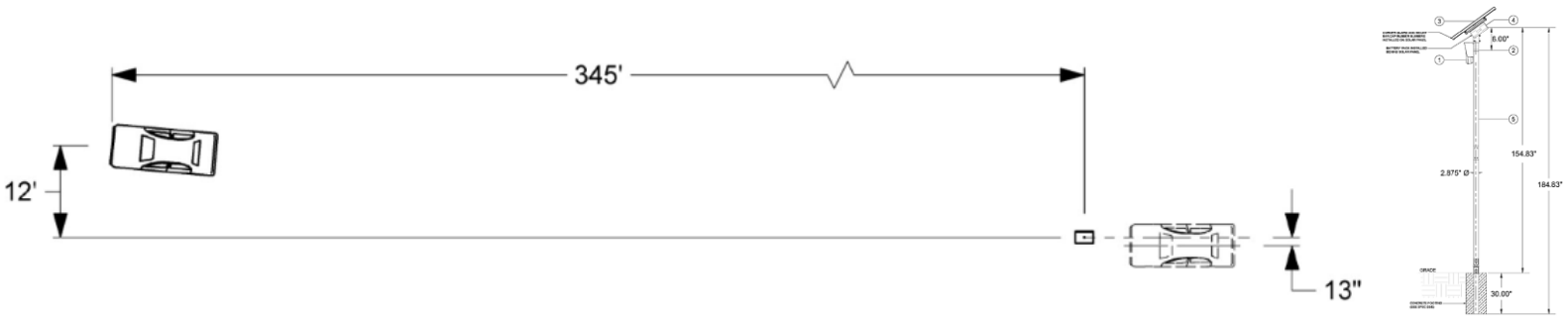


Figure 6.12. Summary of Results for MASH Test 3-61 on Proveli Breakaway Pole System.

CHAPTER 7.

MASH TEST 3-62 (CRASH TEST 690900-PVL-7)

7.1. CRITICAL IMPACT POINT LOCATION

The Critical Impact Point (CIP) for this test was centerline of the vehicle aligned 13 inches off the centerline of the installation towards the left side. The target CIP for this test was determined using the information provided in *MASH* Section 2.2.4.1. Figure 7.1 shows the target CIP for test 690900-PVL-7. Figure 7.2 and Figure 7.3 depict the vehicle at the CIP prior to test 690900-PVL-7.

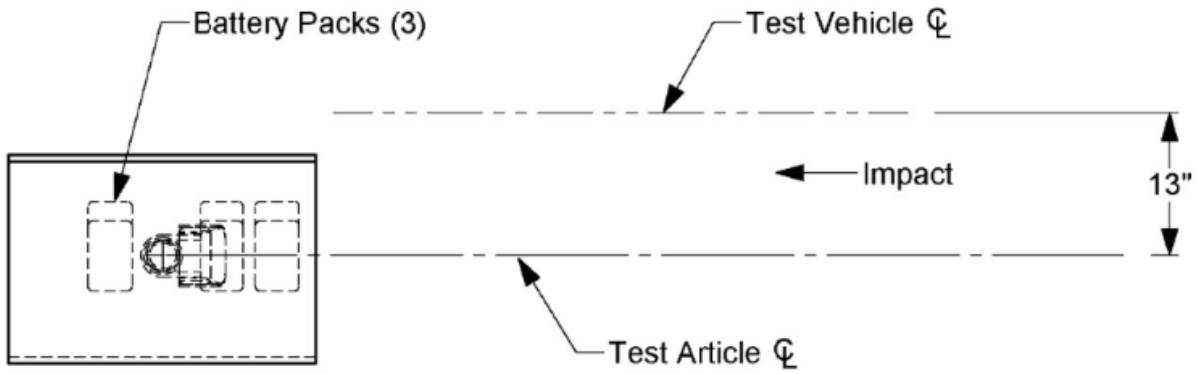


Figure 7.1. Target CIP for *MASH* Test 3-62 on Proveli Breakaway Pole System.

Figure 7.2. Proveli Breakaway Pole System/Test Vehicle Geometrics for Test 690900-PVL-7.

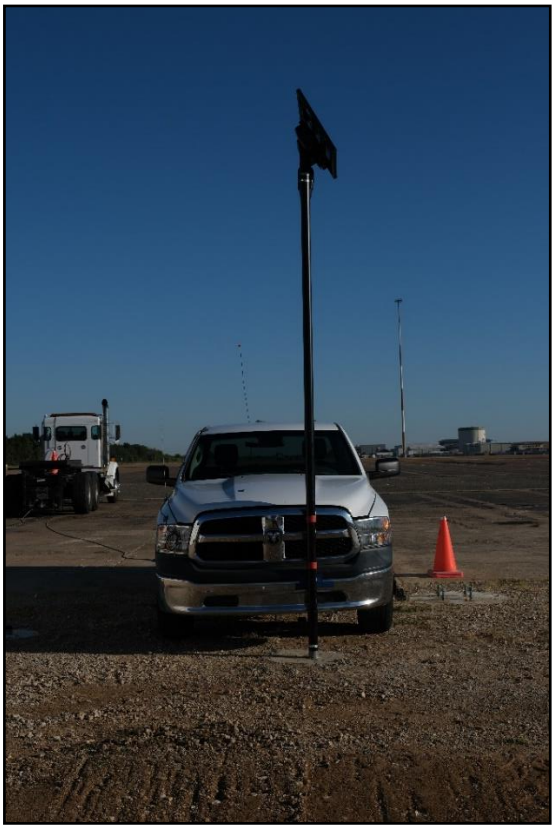


Figure 7.3. Proveli Breakaway Pole System/Test Vehicle Impact Location for Test 690900-PVL-7.

7.2. TEST VEHICLE DETAILS PRIOR TO IMPACT

Table 7.1 shows the vehicle measurements. Figure 7.4 and Figure 7.5 show the 2018 RAM 1500 used for the crash test. Figure E.1 in Appendix E.1 gives additional dimensions and information on the vehicle.

Table 7.1. Vehicle Measurements for Test 690900-PVL-7.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	N/A
Inertial Mass	5000 lb	±110 lb	5031 lb
Gross Static[a] Mass	5000 lb	±110 lb	5031 lb
Wheelbase	148 inches	±12 inches	140.5 inches
Front Overhang	39 inches	±3 inches	40.3 inches
Overall Length	237 inches	±13 inches	229 inches
Overall Width	78 inches	±2 inches	78.5 inches
Hood Height	43 inches	±4 inches	46 inches
Track Width[b]	67 inches	±1.5 inches	68.3 inches
CG aft of Front Axle[c]	63 inches	±4 inches	62.1 inches
CG above Ground[c,d]	28 inches	28 inches	28.8 inches

Note: N/A = not applicable; CG = center of gravity.

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.

[b] Average of front and rear axles.

[c] For test inertial mass.

[d] 2270P vehicle must meet minimum CG height requirement.

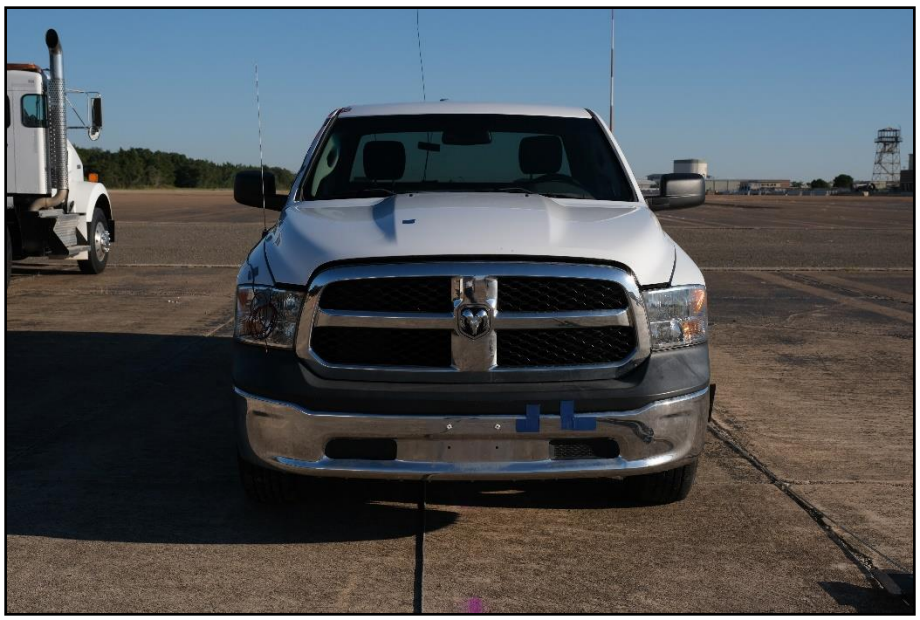


Figure 7.4. Front of Test Vehicle before Test 690900-PVL-7.

Figure 7.5. Rear of Test Vehicle before Test 690900-PVL-7.

7.3. TEST DESCRIPTION

7.3.1. Weather Conditions

Table 7.2 provides the weather conditions for test 690900-PVL-7.

Table 7.2. Weather Conditions for Test 690900-PVL-7.

Date of Test	9/27/2024
Wind Speed	8 mi/h
Wind Direction	300°
Temperature	76 °F
Relative Humidity	66 %
Vehicle Traveling	170°

7.3.2. Test Events

Table 7.3 lists events that occurred during Test 690900-PVL-7. Figures E.4, E.5, and E.6 in Appendix E.2 present sequential photographs during the test.

Table 7.3. Events during Test 690900-PVL-7.

Time	Events
0.0000 s	Vehicle impacted the installation
0.0040 s	Pole began to move
0.0090 s	Pole began to release from base
0.0150 s	Pole released from base
0.0200 s	Solar panel and camera released from support pole
0.1340 s	Post impacted the roof at windshield

7.4. TEST ACTUAL IMPACT CONDITIONS

Table 7.4 lists the details of the *MASH* impact conditions for this test and Table 7.5 lists the exit parameters.

Table 7.4. Impact Conditions for *MASH TEST 3-62,* Crash Test 690900-PVL-7.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	62.7 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	594 kip-ft	≥594 kip-ft	661.2 kip-ft
Impact Location	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the left side	±6 inches	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the left side

Table 7.5. Exit Parameters for *MASH TEST 3-62,* Crash Test 690900-PVL-7.

Exit Parameter	Measured
Speed	61.7 mi/h
Brakes applied post impact	2.5 seconds
Vehicle at rest position	431 ft downstream of impact point In line with the impact path
Comments:	Vehicle remained upright and stable.

7.5. DAMAGE TO TEST INSTALLATION

The base of the footer was deformed, and the lower portion of the support pole sheared. The support pole came to rest 360 feet downstream and 50 feet to the left of the original location of the installation. The lower and upper portions of the support pole were deformed. The solar panel and camera released from the support pole and came to rest at the original location of the installation. Figure 7.6 and Figure 7.7 show the damage to the Proveli Breakaway Pole System.

Figure 7.6. Proveli Breakaway Pole System Base at Impact Location after Test 690900-PVL-7.

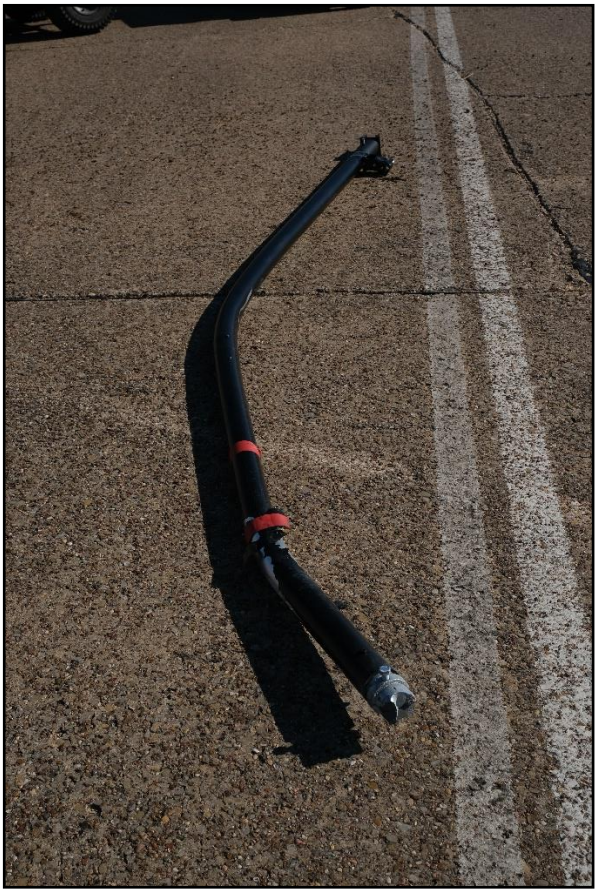


Figure 7.7. Proveli Breakaway Pole System after Test 690900-PVL-7.

7.6. DAMAGE TO TEST VEHICLE

Figure 7.8 and Figure 7.9 show the damage sustained by the vehicle. Figure 7.10 and Figure 7.11 show the interior of the test vehicle. Table 7.6 and Table 7.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures E.2 and E.3 in Appendix E.1 provide exterior crush and occupant compartment measurements.

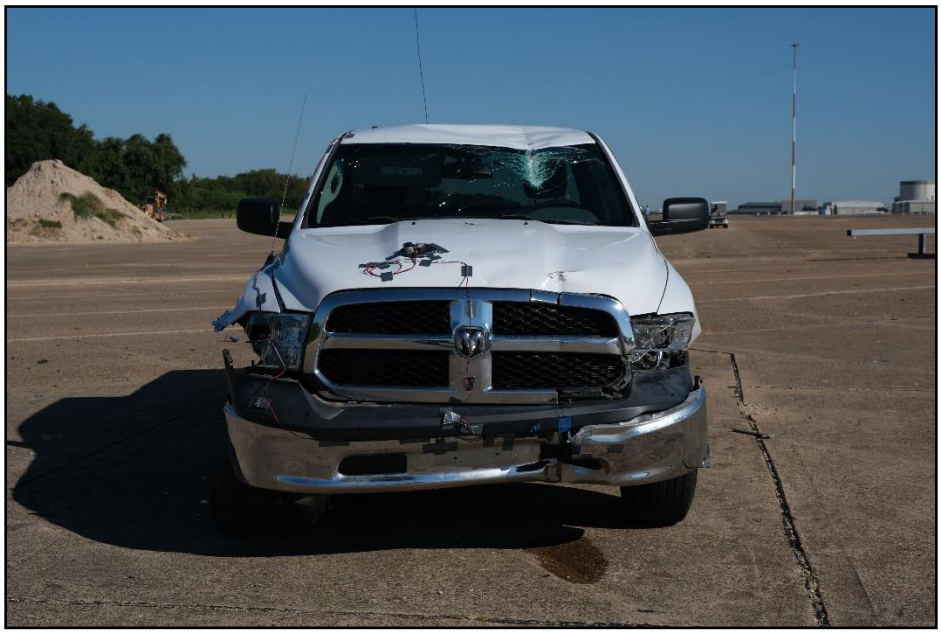


Figure 7.8. Front of Test Vehicle after Test 690900-PVL-7.

Figure 7.9. Test Vehicle Roof after Test 690900-PVL-7.

Figure 7.10. Overall Interior of Test Vehicle after Test 690900-PVL-7.

Figure 7.11. Windshield Damage after Test 690900-PVL-7.

Table 7.6. Occupant Compartment Deformation for Test 690900-PVL-7.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	2.8 inches
Windshield	≤3.0 inches	1.8 inches
A and B Pillars	≤5.0 overall/≤3.0 lateral inches	0.0 inches
Foot Well/Toe Pan	≤9.0 inches	0.0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0.0 inches
Side Front Panel	≤12.0 inches	0.0 inches
Front Door (above Seat)	≤9.0 inches	0.0 inches
Front Door (below Seat)	≤12.0 inches	0.0 inches

Table 7.7. Exterior Vehicle Damage for Test 690900-PVL-7.

Test Parameter	Details
Side Windows	Side windows remained intact
Maximum Exterior Deformation	8 inches in the front plane at bumper height
VDS	12FC2
CDC	12FCEN1
Fuel Tank Damage	None
Description of Damage to Vehicle:	There was a 4-inch-wide × 1.5-inch-deep deformation in the hood on the left side, a 2.5-inch long × 0.5-inch-wide puncture in the center of the hood 11 inches in front of the windshield. The windshield had a 16-inch-long × 16-inch wide and maximum 1.8-inch-deep fracture and deformation. There were no punctures or tears in the laminate. The roof had a 29-inch-long × 26-inch wide × 2.8-inch-deep deformation on the front left side. The bumper and grill were also damaged.

7.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 7.8. Figure E.7 in Appendix E.3 shows the vehicle angular displacements, and Figures E.8 through E.10 in Appendix E.4 show acceleration versus time traces.

Table 7.8. Occupant Risk Factors for Test 690900-PVL-7.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	3.5 ft/s	0.7798 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	1.9 ft/s	0.7798 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	0.2 g	1.3558 - 1.3658 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.4 g	0.8536 - 0.8636 seconds
Theoretical Head Impact Velocity (THIV)	N/A	1.2 m/s	0.7796 seconds on front of interior
Acceleration Severity Index	N/A	0.1	0.0125 - 0.0625 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-1 g	0.0000 - 0.0500 seconds
50-ms MA Lateral	N/A	0.4 g	0.0988 - 0.1488 seconds
50-ms MA Vertical	N/A	-1 g	0.1526 - 0.2026 seconds
Roll	≤75°	1°	1.6875 seconds
Pitch	≤75°	1.9°	1.7904 seconds
Yaw	N/A	1.6°	1.9445 seconds

[a.] *Values in italics are the preferred MASH values*

7.8. TEST SUMMARY

Figure 7.12 summarizes the results of *MASH* Test 690900-PVL-7.

0.000 s

0.1000 s

0.2000 s

0.3000s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-62
Project No.:	690900-PVL-7
Test Date:	9/27/2024

TEST ARTICLE	
Type:	Support Structures
Name:	Proveli Breakaway Pole System
Length:	154-8 inches
Key Materials:	28-inch × 21.3-inch solar panel, camera, 2-inch SCH 40 Galvanized Steel Pipe, 2.87500 × 0.203 wall Aluminum pipe
Soil Type and Condition:	Concrete Footer

TEST VEHICLE	
Type/Designation:	2270P
Year, Make and Model:	2018 RAM 1500
Inertial Mass:	5031 lb
Dummy Mass:	N/A
Gross Static Mass:	5031 lb

IMPACT CONDITIONS	
Impact Speed:	62.7 mi/h
Impact Angle:	0°
Impact Location:	Centerline of the vehicle aligned 13 inches off the centerline of the installation towards the drivers side
Kinetic Energy:	661.2 kip-ft

EXIT CONDITIONS	
Exit Speed:	61.7 mi/h
Stopping Distance:	431 ft downstream In line

VEHICLE DAMAGE	
VDS:	12FC2
CDC:	12FCEN1
Max Exterior Deformation:	8 inches in the front plane at bumper height
Max Occupant Compartment Deformation:	2.8 inches in the roof

OCCUPANT RISK VALUES	
Longitudinal OIV:	3.5 ft/s
Lateral OIV:	1.9 ft/s
Longitudinal Ridedown:	0.2 g
Lateral Ridedown:	0.4 g
THIV:	1.2 m/s
ASI:	0.1
Max 50ms Longitudinal:	-1 g
Max 50ms Lateral:	0.4 g
Max 50ms Vertical:	-1 g
Max Roll:	1°
Max Pitch:	1.9°
Max Yaw:	1.6°

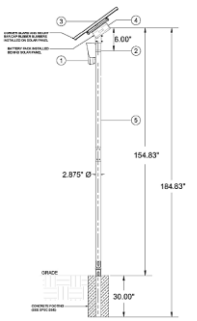


Figure 7.12. Summary of Results for MASH Test 3-62 on Proveli Breakaway Pole System.

CHAPTER 8.

SUMMARY AND CONCLUSIONS

The crash tests reported herein were performed in accordance with *MASH* TL-3, which involves three tests, on the Proveli Breakaway Pole System.

Table 8.1 shows that the Proveli Breakaway Pole System met the performance criteria for *MASH* TL-3 Support Structures.

Table 8.1. Assessment Summary for *MASH* TL-3 Tests on Proveli Breakaway Pole System.

Evaluation Criteria	**Description**	**Test 690900-PVL-5** *(MASH* Test 3-60)	**Test 690900-PVL-6** *(MASH* Test 3-61)	**Test 690900-PVL-7** *(MASH* Test 3-62)
B	Test Article Broke Away, Fractured, Yielded	S	S	S
D	No Penetration into Occupant Compartment	S	S	S
F	Roll and Pitch Limit	S	S	S
H	OIV Threshold	S	S	S
I	Ridedown Threshold	S	S	S
N	Vehicle Trajectory Behind Test Article Acceptable	S	S	S
Overall	Evaluation	Pass	Pass	Pass

Note: S = Satisfactory;
[1] See Table 3.2 for details

REFERENCES

1. AASHTO. *Manual for Assessing Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.

APPENDIX A.

DETAILS OF PROVELI BREAKAWAY POLE SYSTEM

DESIGN NOTES

1. POLE AND FOUNDATIONS ARE DESIGNED IN ACCORDANCE WITH THE FOLLOWING CODES:
   - 1.1. 2021 INTERNATIONAL BUILDING CODE
   - 1.2. AASHTO LRFD SPECIFICATIONSFOR STRUCTURAL SUPPORT FOR HIGHWAY SIGNS, LUMIN, TRAFFIC SIGNALS, 2015 EDITION.
2. POLE ANALYSIS AND FOUNDATION DESIGN ARE BASED ON THE FOLLOWING CRITERIA
   - 2.1. DESIGN WIND SPEED (Vult)): (SEE SECTION 2.6)
   - 2.2. RISK CATEGORY: II
   - 2.3. EXPOSURE CATEGORY: C
   - 2.4. TOPOGRAPHIC CATEGORY: 1
   - 2.5. SEISMIC DESIGN CRITERIA:
     - 2.5.1. SOIL SITE CLASS: D (ASSUMED)
     - 2.5.2. SPECTRAL RESPONSE, Ss: 1.000g (MAXIMUM)
     - 2.5.3. SPECTRAL RESPONSE, S1: 0.400G (MAXIMUM)
     - 2.5.4. SEISMIC DESIGN CATEGORY: B
   - 2.6. STRUCTURE BASE REACTIONS ARE CALCULATED AS FOLLOWS:

DESIGN WIND SPEED (MPH)	MOMENT (K-FT)	SHEAR (KIP)	AXIAL (KIP)
115	2.70	0.280	0.160
125	3.20	0.330	0.160
135 (MAX)	3.70	0.380	0.160

   - 2.7. SHOULD ANY OF THE SITE-SPECIFIC PARAMETERS BE HIGHER THAN WHAT IS NOTED ABOVE, THE EOR SHALL BE CONTACTED TO PROVIDE A REVISED DESIGN.
3. CONTRACTOR IS RESPONSIBLE FOR VERIFYING SOIL CONDITIONS PRIOR TO INSTALLATION.
4. FOUNDATION TO CONSIST OF CONCRETE SURROUNDING THE PROPSED POLE WITH A MINMUM OF 3,000-PSI COMPRESSIVE STRENGTH.

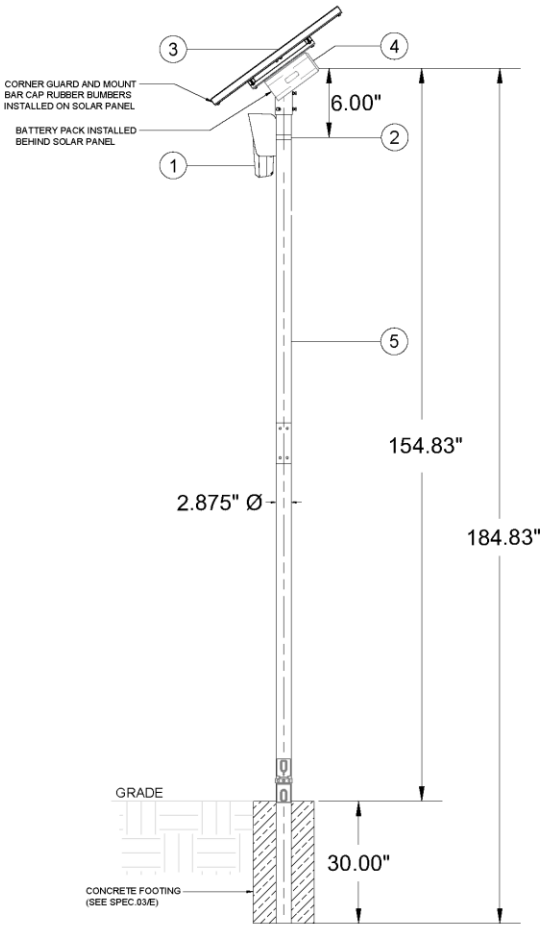
GENERAL & CONSTRUCTION NOTES

1. CONTRACTOR SHALL CONTACT DESIGNATED AGENCY TO LOCATE ALL UNDERGROUND UTILITIES PRIOR TO CONSTRUCTION.
2. CONTRACTOR SHALL APPLY AND OBTAIN AN APPROVED TRAFFIC CONTROL PLAN IN ACCORDANCE WITH MUTCD AND LOCAL JURISDICTION STANDARDS.
3. CONTRACTOR SHALL RESTORE ALL DISTURBED AREAS TO ORIGINAL SITE CONDITION TO THE SATISFACTION OF STATE DEPARTMENT OF TRANSPORTATION AND LOCAL JURISDICTION.
4. ALL WORK SHALL CONFORM TO APPLICABLE ELECTRICAL CODES EXCEPT WHEN STATE DEPARTMENT OF TRANSPORTATION OR LOCAL JURISDICTION STANDARDS SUPERSEDE.
5. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH SPECIFICATIONS DEFINED BY THE STATE DEPARTMENT OF TRANSPORTATION OR LOCAL JURISDICTION, UNLESS SPECIFICALLY STATED OR SHOWN OTHERWISE HEREIN.

ADA COMPLIANCE NOTES

1. ALL SIDEWALK CONSTRUCTION SHALL BE IN ACCORDANCE WITH ADA TITLE II, STATE DEPARTMENT OF TRANSPORTATION, AND LOCAL JURISDICTION STANDARDS,
2. STATE DEPARTMENT OF TRANSPORTATION CURRENT EDITION STANDARDS SHALL BE USED FOR PEDESTRIAN CONTROL PLANS WHEN CLOSURE OF SIDEWALK IS REQUIRED FOR CONSTRUCTION.
3. MINIMUM CLEAR PEDESTRIAN ACCESS ROUTE (PAR) SHALL BE 48" WIDE.
4. NO OBSTRUCTION IS PERMITTED ALONG THE WIDTH OF THE SIDEWALK. UP TO AN ELEVATION OD 7'-0" ABOVE GRADE.

ITEM NO.	PART NUMBER	DESCRIPTION	TOTAL WEIGHT (LB)	QTY.
1	701-0059	FLOCK SAFETY CAMERA	3.6	1
2	201-00097	MOUNTING CLAMP	2.0	1
3	702-00080	65W SOLAR KIT	18.0	1
4	702-00028 / 701-00111	BATTERY PACK	4.0 (APPROX)	3 (MAX)
5	1020-01	PROVELI BREAKAWAY STYLE 7 COUPLER ASSEMBLY	229.39	1



1 POLE ELEVATION DETAIL

SCALE: N/A

flock safety

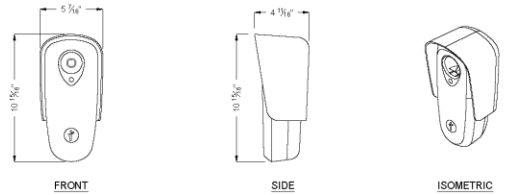
1170 HOWELL MILL ROAD SUITE 210
ATLANTA, GA 30318

REV	DATE	BY	DESCRIPTION
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
0	09/05/2024	JMW	TYP DETAIL

LICENSE PLATE READER CAMERA INSTALLATION

SHEET:	REV:
SPEC.01	0

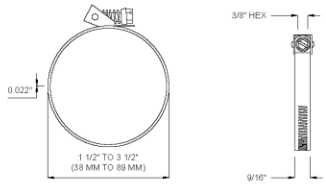
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF FLOCK SAFETY. ANY REPRODUCTION IN PART OR IN WHOLE WITHOUT THE WRITTEN PERMISSION OF FLOCK SAFETY IS PROHIBITED. DO NOT SCALE DRAWINGS.



SUPPLIED BY FLOCK SAFETY
MODEL 701-00059
WEIGHT: 3.5 LB
MOUNTING HARDWARE: MCMASTER-CARR QUICK-RELEASE CLAMP PART # 5322K58 OR AN APPROVED EQUIVALENT

1 FLOCK AUTOMATIC LICENSE PLATE READER CAMERA

Scale: N/A

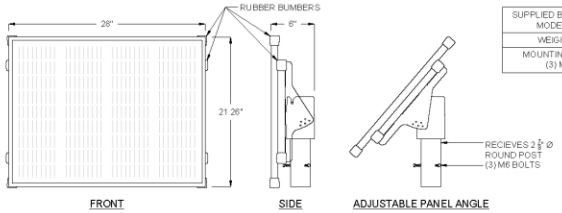


MANUFACTURER: MCMASTER-CARR QUICK-RELEASE CLAMP PART # 5322K58 OR AN APPROVED EQUIVALENT
130 MPH WIND RATING

NOTE: LARGER DIAMETER POLES WILL USE AN EQUIVALENT 201 STAINLESS STEEL STRAPPING CUT TO LENGTH.

2 MOUNTING CLAMP

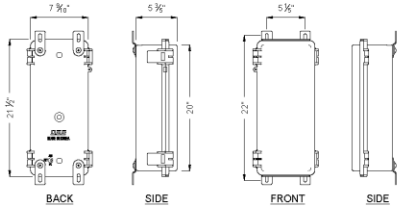
Scale: N/A



SUPPLIED BY FLOCK SAFETY
MODEL 702-00080
WEIGHT: 18 LB
MOUNTING HARDWARE: (3) M6 BOLTS

3 65 WATT SOLAR PANEL AND MOUNT ASSEMBLY (TOP MOUNTED)

Scale: N/A



SUPPLIED BY FLOCK SAFETY
MODEL 701-00111
WEIGHT: 3.5 LB (APPROX)
MOUNTING HARDWARE: MCMASTER-CARR QUICK-RELEASE CLAMP PART # 5322K58 OR AN APPROVED EQUIVALENT

4 EXTERNAL BATTERY PACK

SCALE: N/A

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1170 HOWELL MILL ROAD SUITE 210
ATLANTA, GA 30318

REV	DATE	BY	DESCRIPTION
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
0	09/05/2024	JMW	TYP DETAIL

LICENSE PLATE READER CAMERA INSTALLATION

SHEET:	REV:
SPEC.02	0

ITEM NO.	DESCRIPTION	QTY.
1	0.250-20 X 0.750 BT TX TAMPER-RESISTANT	6
2	2" SCH 40 2.375OD 0.154WALL - GALVANIZED STEEL	1
3	2.875OD X 0.203 WALL X 33.000L - 6061-T6 ALUMINUM	1
4	2.875OD X 0.203 WALL X 60.875L - 6061-T6 ALUMINUM	1
5	2.875OD X 0.203 WALL X 90.000L - 6063-T52 ALUMINUM	1
6	BRAIDED SLEEVE	1
7	BREAKAWAY ROUND POST 2.875OD	1
8	CONCRETE FOOTING	1
9	HBOLT ANTI ROTATION	1
10	INSERT SLEEVE STYLE 7 TAPPED	1
11	ORING SQ	1
12	WASHER 0.250 SPLIT LOCK 0.260 X 0.487 X 0.062	6
13	BOLT 0.250-20 X 3.500 X 0.750 HX BLACK WITH NUT 0.250-20 HX BLACK	1

PROVELI MASH DETAILS

BREAKAWAY STYLE 7 COUPLER ASSEMBLY

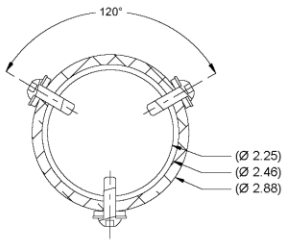
PART #: SP-7/MASH

MATERIAL: VARIES

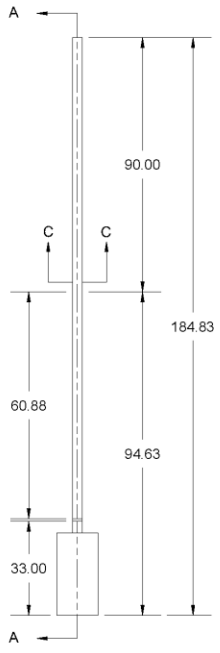
WEIGHT: 229.39 LBS

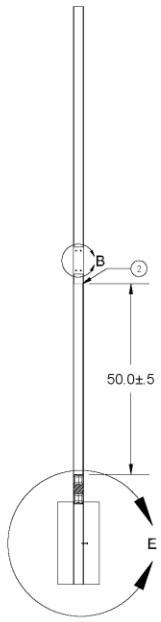
DATE: 01/11/2024

DO NOT SCALE DRAWINGS (NTS)

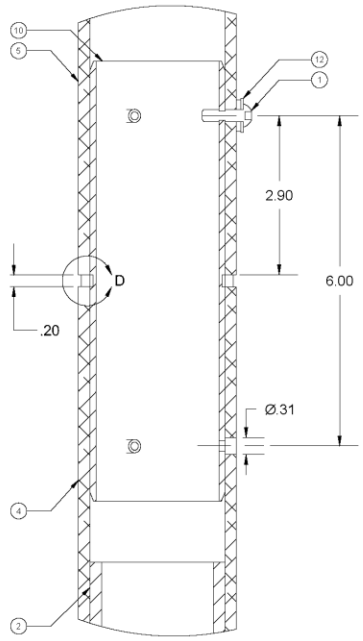


SECTION C-C

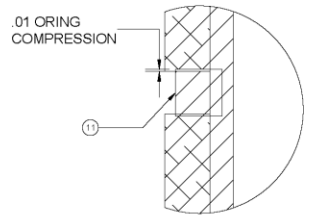




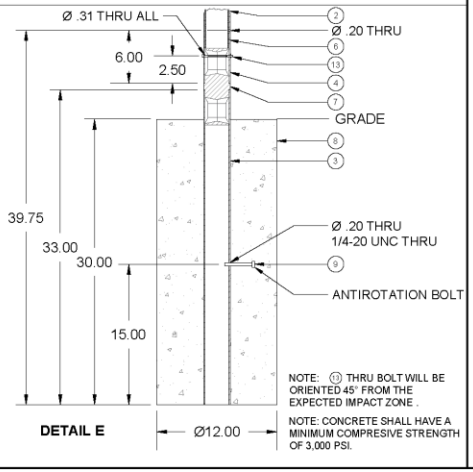
SECTION A-A



DETAIL B



DETAIL D



DETAIL E

flock safety
1170 HOWELL MILL ROAD SUITE 210
ATLANTA, GA 30318

REV	DATE	BY	DESCRIPTION
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
0	09/05/2024	JMW	TYP DETAIL

LICENSE PLATE READER CAMERA INSTALLATION

SHEET:	REV:
SPEC.03	0

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF FLOCK SAFETY. ANY REPRODUCTION IN PART OR IN WHOLE WITHOUT THE WRITTEN PERMISSION OF FLOCK SAFETY IS PROHIBITED. DO NOT SCALE DRAWINGS.

APPENDIX B.

SUPPORTING CERTIFICATION DOCUMENTS

Texas A&M Transportation Institute	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Revision Date: 2020-07-29
Quality Form	Revised by: B.L. Griffith Approved by: D. L. Kuhn	Revision: 7	Page: 1 of 1

Project No: 690900-PVL5-7 **Casting Date:** 9/17/2024 **Mix Design (psi):** 3000

Name of Technician Taking Sample: Terracon

Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Castillo,Jul5	99297	100% of footers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average

TEXCRETE
Redi-mix Concrete Company

204896

REMIT PAYMENT TO:
P.O. BOX138
KURTEN, TX 77862

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO RT 2818, RT HWY 21, LT SILVER HILL, RT AT
RELLIS CAMPUS, BRYAN TX THE "T", RT HWY 47, LT INTO RELLIS ENTRANCE,
STAY STRAIGHT ALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
12:06	CN940CC050	3.00	3.00	PO#	CASTILLO, JULS		99297
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
9/17/24	PROJECT TTIRELL	3.00	3.00			5.00 in	97500

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
3.00 yd	CN940CC0500	COM, 4000, BLND, 5"		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
12:17	12:35				

FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	ON SITE TESTING
			TESTING LAB: TERRACON GESSNER CME OTHER

TESTED	AIR	CYLINDERS
☐ YES ☐ NO		

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

Contains Portland Cement. Wear Rubber Boots and Gloves. PROLONGED CONTACT MAY CAUSE BURNS. Avoid Contact With Eyes and Prolonged Contact with Skin. In Case of Contact with Skin or Eyes, Rinse Thoroughly With Water. If Irritation Persists, Get Medical Attention. **KEEP CHILDREN AWAY.**

CONCRETE is a PERISHABLE COMMODITY and BECOMES THE PROPERTY of the PURCHASER UPON LEAVING the PLANT. ANY CHANGES or CANCELLATION of ORIGINAL INSTRUCTIONS MUST be TELEPHONED to the OFFICE BEFORE LOADING starts. The undersigned promises to pay all costs, including reasonable attorney's fees, incurred in collecting any sums owed.

All accounts not paid within 30 days of delivery will bear interest at the rate of 18% per annum. Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Made at Time Material is Delivered.
A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demurge charge after 90 min. will be $100.00/hr

PROPERTY DAMAGE RELEASE
(TO BE SIGNED IF DELIVERY TO BE MADE INSIDE CURB LINE)

Dear Customer – The driver of this truck in presenting this RELEASE to you for your signature is of the opinion that the size and weight of this truck may possibly cause damage to the premises and/or adjacent property if he places the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver is requesting that you sign this RELEASE relieving him and this supplier from any responsibility from damage that may occur to the premises and or adjacent property, buildings, sidewalks, driveways, curbs, etc. by the delivery of this material and that you also agree to help him remove mud from the wheels of his vehicle so that he will not litter the public streets. Further as additional consideration; the undersigned agrees to indemnify and hold harmless the driver of this truck and this supplier for any and all damage to the premises and /or adjacent property which may be claimed by anyone to have arisen out of delivery of this order

SIGNED:

X _____

Excessive Water is Detrimental to Concrete Performance.
H_2O Added by Request/Authorized By:

GAL X _____

WEIGHMASTER

Surcharge for credit cards

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE HEALTH WARNING NOTICE AND SUPPLIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE CAUSED WHEN DELIVERING INSIDE CURB LINE.

LOAD RECEIVED BY

x _____

204896

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0310
Service Date: 09/17/24
Report Date: 10/24/24
Task: PO# 690900-PLV-7

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

Client
Texas Transportation Institute
Attn: Bill Griffith
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength:
Mix ID:
Supplier:
Batch Time: **Plant:**
Truck No.: **Ticket No.:**

Sample Information

Sample Date: 09/17/24 **Sample Time:**
Sampled By: Bryson Rodriguez
Weather Conditions: Clear, Light Wind
Accumulative Yards: 10/10 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Bottom of West Pier
Placement Location: 690900-PLV-7 Barrier Piers
Sample Description: 4-inch diameter cylinders

Field Test Data

Test	Result	Specification
Slump (in):	6	
Air Content (%):	2.1	
Concrete Temp. (F):	87	
Ambient Temp. (F):	90	
Plastic Unit Wt. (pcf):		
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	4.00	12.57	09/18/24	10/24/24	37	41,927	3,340	3	JLR
1	B	Good	4.00	12.57	09/18/24	10/24/24	37	43,922	3,490	3	JLR
1	C	Good	4.00	12.57	09/18/24	10/24/24	37	45,179	3,590	2	JLR
1	D	Good	4.00	12.57	09/18/24	10/24/24	37	42,657	3,390	3	JLR
							Average (37 days)		**3,460**		
1	E				09/18/24		Hold				

Initial Cure: Onsite Cooler **Final Cure:** Field Cured

Comments: **Not tested for plastic unit weight.**
Note: Reported air content does not include Aggregate Correction Factor (ACF).
Ticket was not obtained

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).

Terracon Rep.: Bryson Rodriguez
Reported To: Adam Mayer w/ TTI
Contractor:
Start/Stop:

Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Reviewed By:
Justin Maass
Assistant Project Manager

Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

APPENDIX C.

MASH TEST 3-60
(CRASH TEST 690900-PVL-5)

C.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-09-27 Test No.: 690900-PVL-5 VIN No.: 3N1CN7APOKL815309

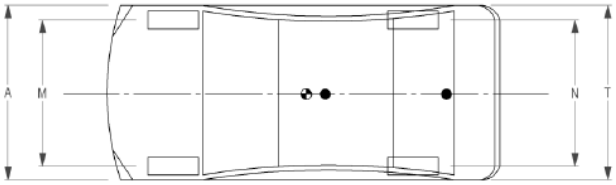
Year: 2019 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 85518 Tire Size: P185/65R15

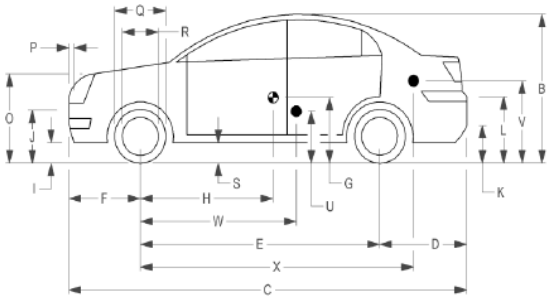
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None



Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None



Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: PASSENGER SIDE

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	41.11	M	58.30	R	16.25	W	41.00
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		

Wheel Center Ht Front 11.50 Wheel Center Ht Rear 11.50 W-H -0.11

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches
(M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1436	1446	1531
Back	1687	M_{rear}	996	970	1050
Total	3389	M_{Total}	2432	2416	2581

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 706 RF: 740 LR: 501 RR: 469

Figure C.1. Vehicle Properties for Test 690900-PVL-5.

Date: 2024-09-27 Test No.: 690900-PVL-5 VIN No.: 3N1CN7APOKL815309

Year: 2019 Make: Nissan Model: Versa

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
-	-	-	-	-	-	-	-	-	-	-	-
	Measurements recorded										
	☑ inches or ☐ mm										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

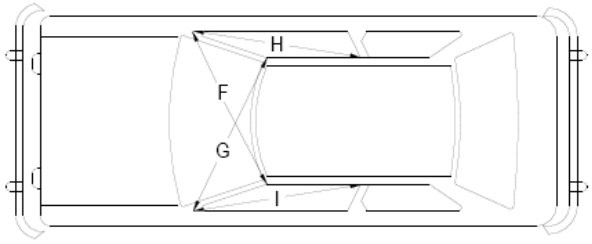
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

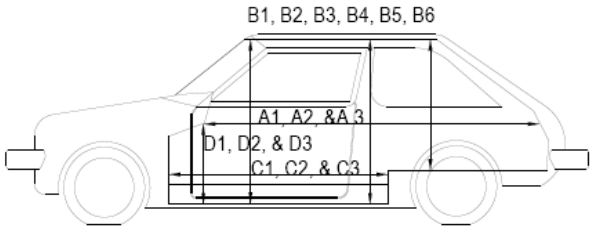
***Measure and document on the vehicle diagram the location of the maximum crush.

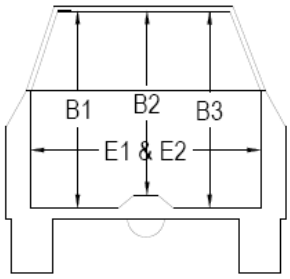
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure C.2. Exterior Crush Measurements for Test 690900-PVL-5.

Date:	2024-09-27	Test No.:	690900-PVL-5	VIN No.:	3N1CN7APOKL815309
Year:	2019	Make:	Nissan	Model:	Versa







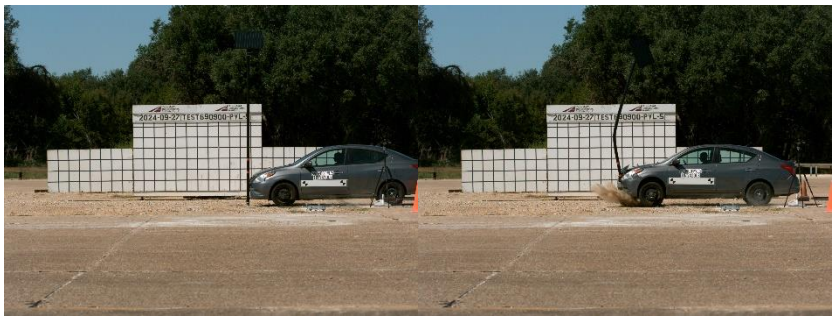
OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	40.50	0.00
B2	39.00	39.00	0.00
B3	40.50	40.50	0.00
B4	36.25	36.25	0.00
B5	36.00	36.00	0.00
B6	36.25	36.25	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

*Lateral area across the cab from driver's side kick panel to passenger's side kick panel.

Figure C.3. Occupant Compartment Measurements for Test 690900-PVL-5.

C.2. SEQUENTIAL PHOTOGRAPHS



(a) 0.000 s (b) 0.1500 s

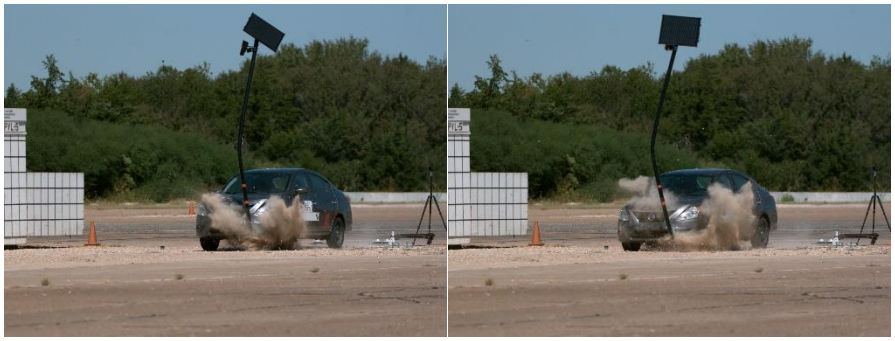
(c) 0.3000 s (d) 0.4500 s

(e) 0.6000 s (f) 0.7500 s

(g) 0.9000 s (h) 1.0500 s

Figure C.4. Sequential Photographs for Test 690900-PVL-5 (Right Angle Views).

(a) 0.000 s (b) 0.1500 s



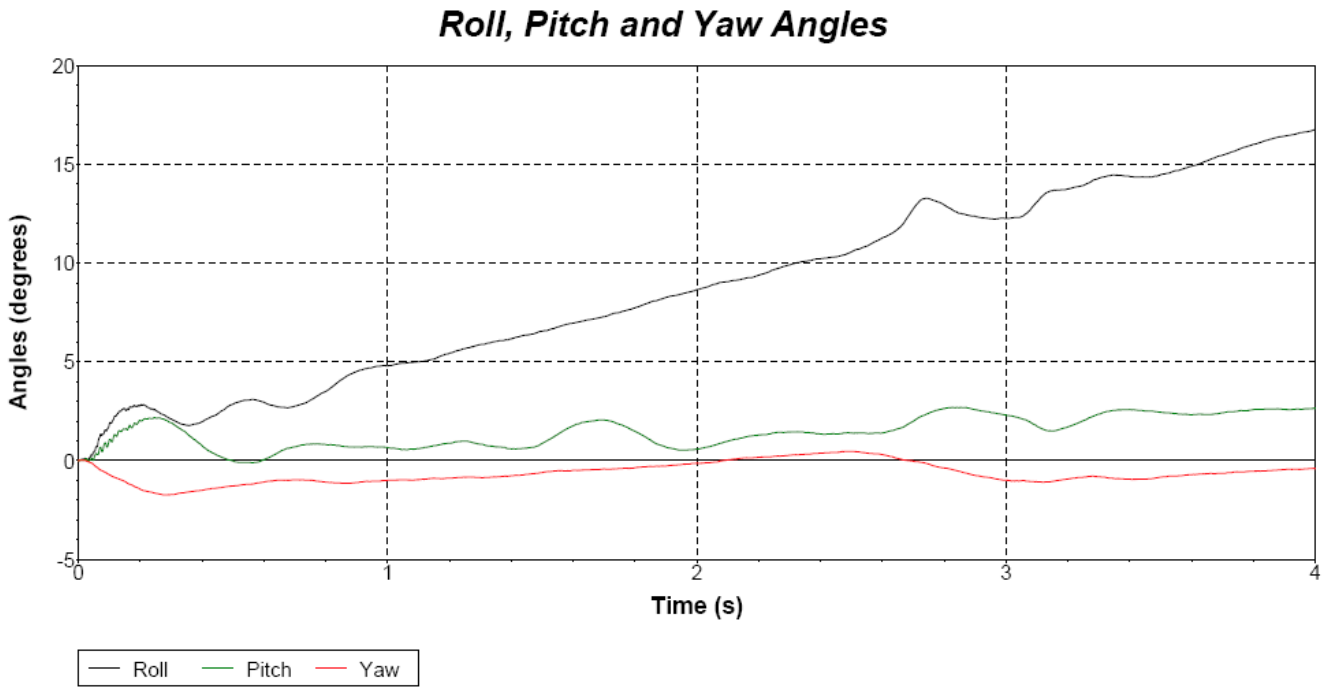
(c) 0.3000 s (d) 0.4500 s

(e) 0.6000 s (f) 0.7500 s

(g) 0.9000 s (h) 1.0500 s

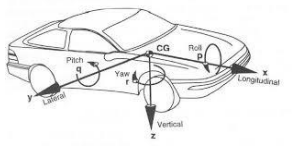
Figure C.5. Sequential Photographs for Test 690900-PVL-5 (Downstream Oblique Views).

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

1. Yaw.
2. Pitch.
3. Roll



Test Number: 690900-PVL-5
Test Standard Test Number: *MASH* Test 3-60
Test Article: Breakaway Pole System
Test Vehicle: 2019 Nissan Versa
Inertial Mass: 2441 lbs
Gross Mass: 2606 lbs
Impact Speed: 18.8 mi/h
Impact Angle: 0°

Figure C.6. Vehicle Angular Displacements for Test 690900-PVL-5.

C.4. VEHICLE ACCELERATIONS

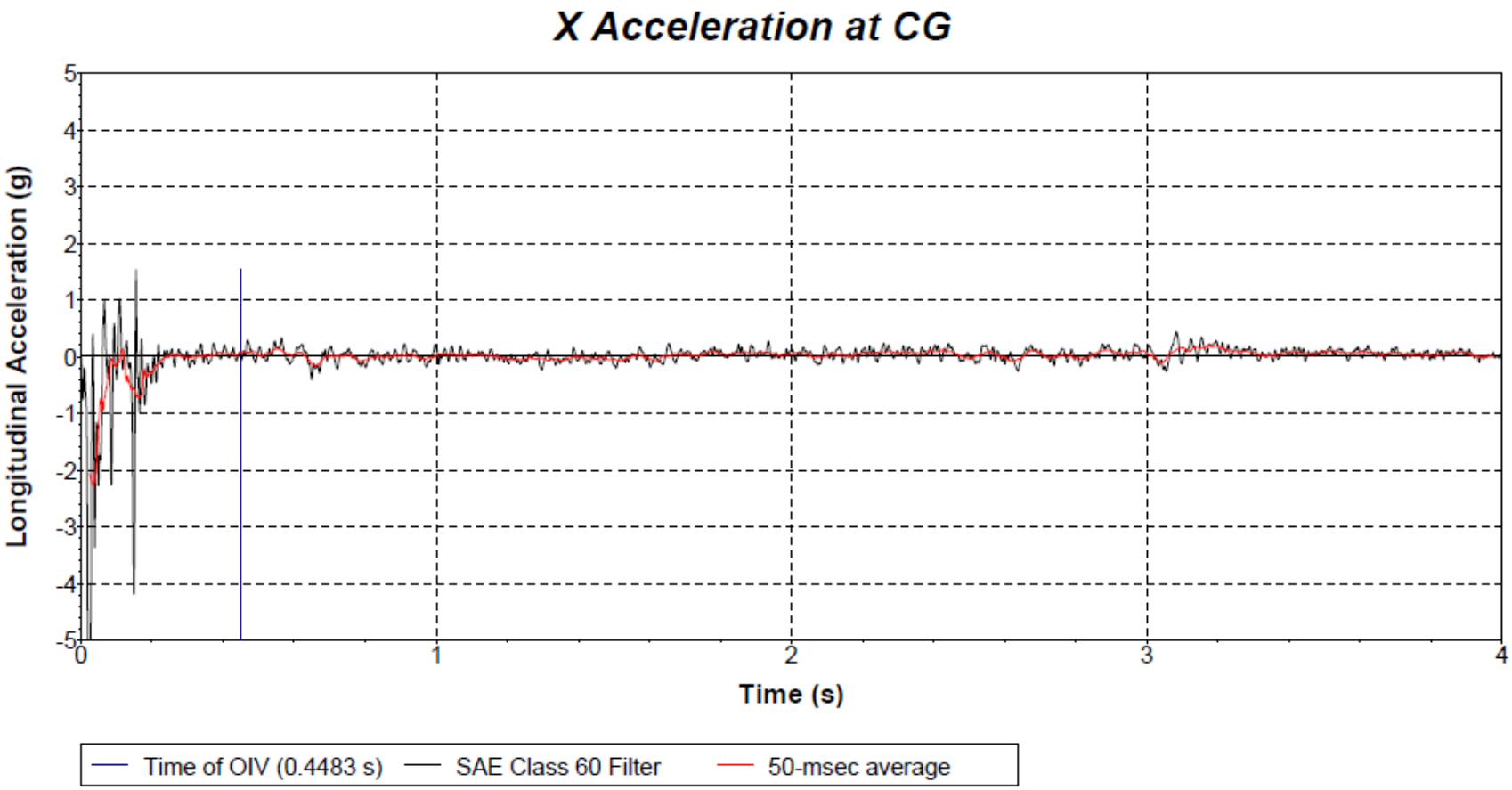


Figure C.7. Vehicle Longitudinal Accelerometer Trace for Test 690900-PVL-5 (Accelerometer Located at Center of Gravity).

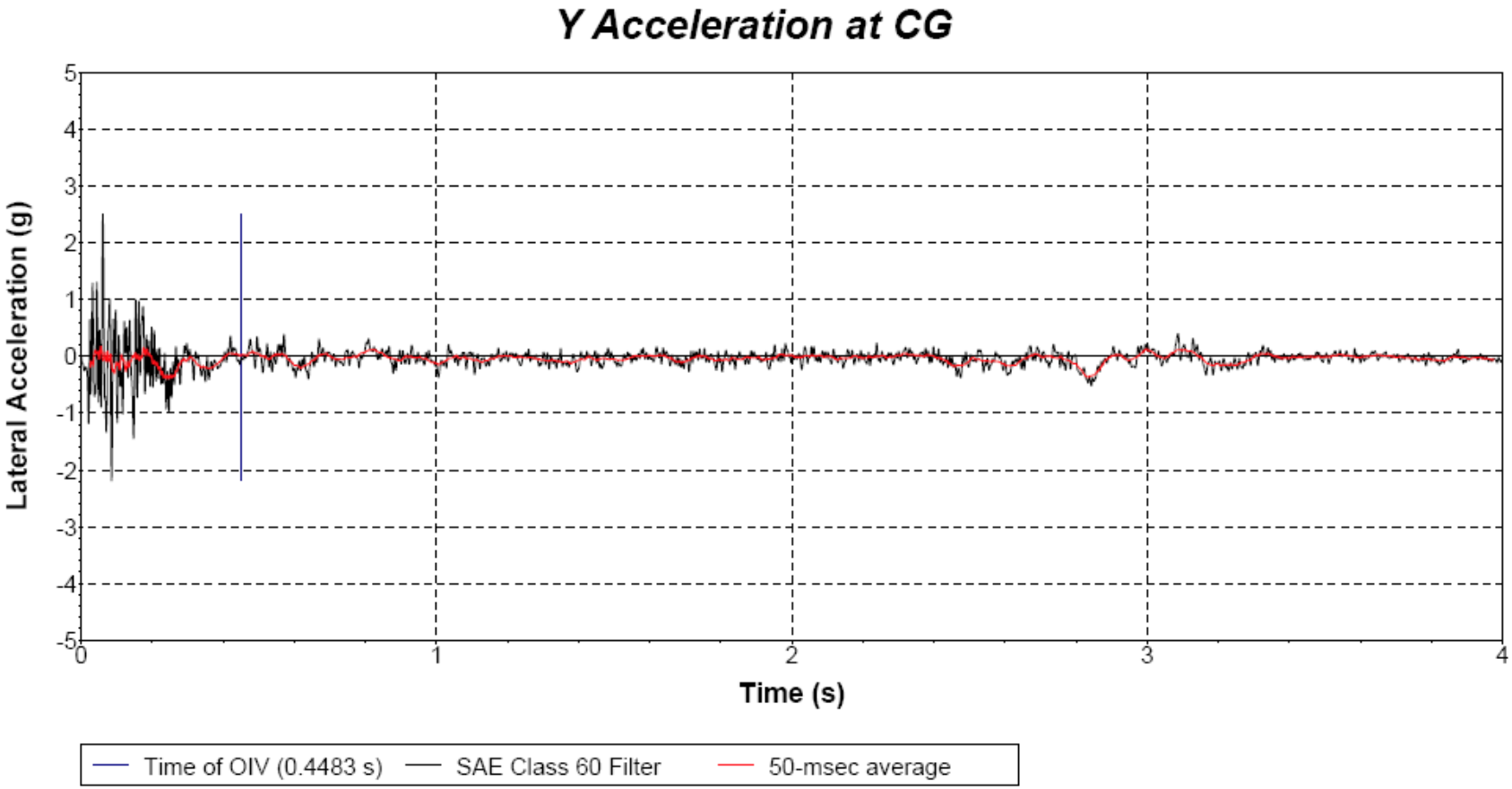


Figure C.8. Vehicle Lateral Accelerometer Trace for Test 690900-PVL-5 (Accelerometer Located at Center of Gravity).

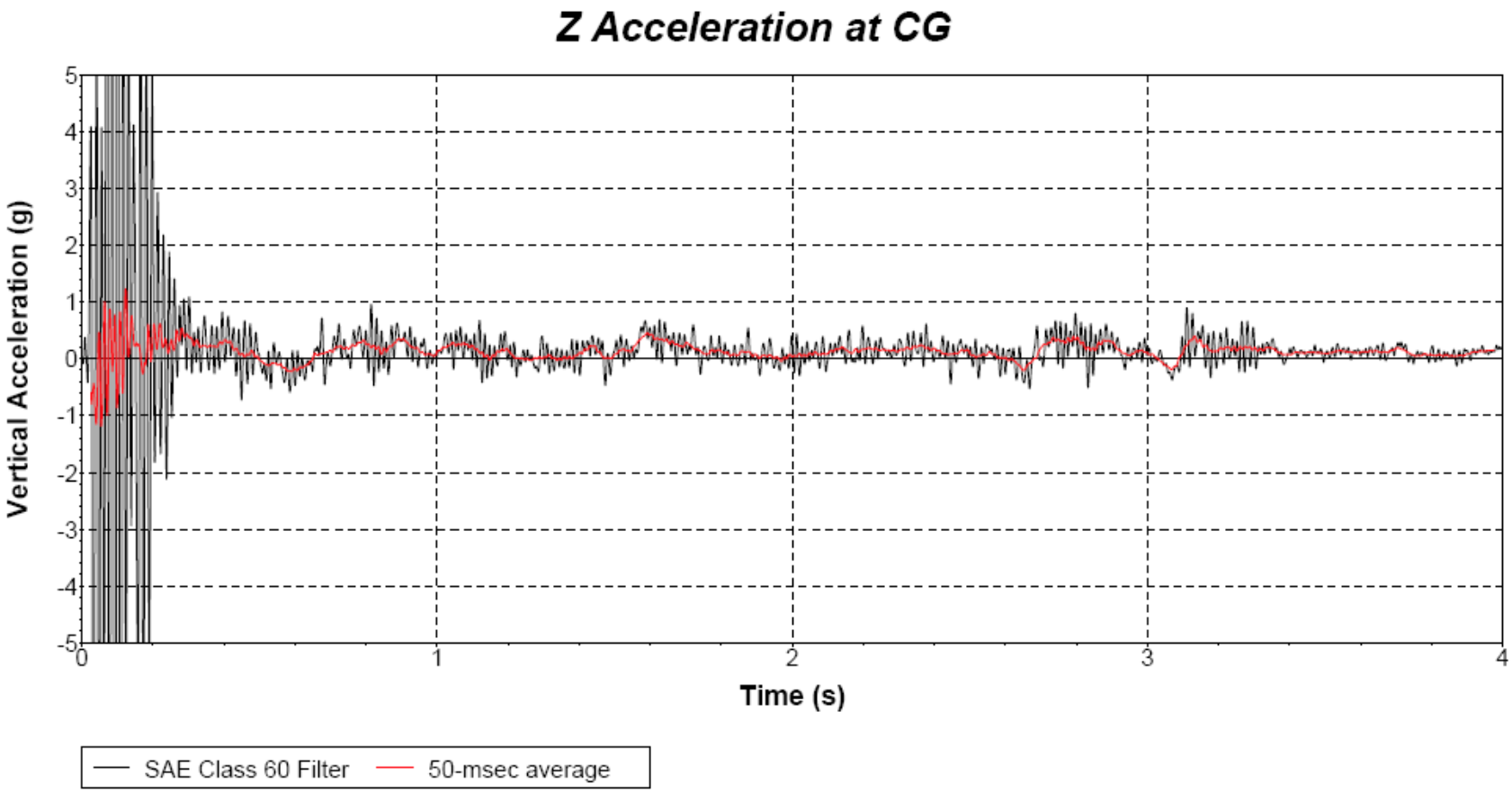


Figure C.9. Vehicle Vertical Accelerometer Trace for Test 690900-PVL-5 (Accelerometer Located at Center of Gravity).

APPENDIX D.

MASH TEST 3-61
(CRASH TEST 690900-PVL-6)

D.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-09-27 Test No.: 690900-PVL-6 VIN No.: 3N1CN7APOKL815309

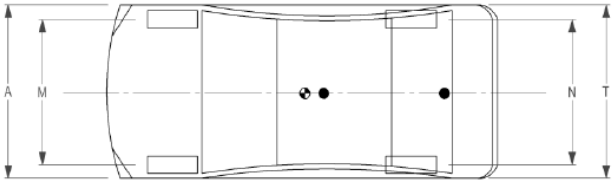
Year: 2019 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 85519 Tire Size: P185/65R15

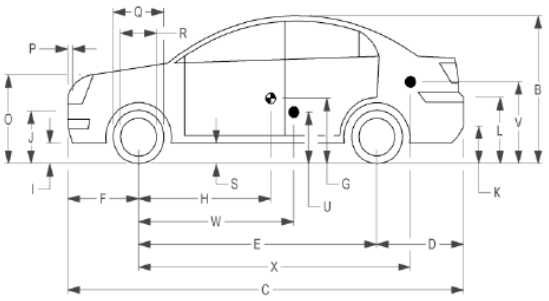
Describe any damage to the vehicle prior to test: None

• Denotes accelerometer location.

NOTES: None



Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None



Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: DRIVERS SIDE

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	41.11	M	58.30	R	16.25	W	41.00
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		

Wheel Center Ht Front 11.50 Wheel Center Ht Rear 11.50 W-H -0.11

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches
(M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:	Mass: lb	Curb	Test Inertial	Gross Static
Front 1750	M_{front}	1436	1446	1531
Back 1687	M_{rear}	996	970	1050
Total 3389	M_{Total}	2432	2416	2581

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 706 RF: 740 LR: 501 RR: 469

Figure D.1. Vehicle Properties for Test 690900-PVL-6.

Date:	2024-09-27	Test No.:	690900-PVL-6	VIN No.:	3N1CN7APOKL815309
Year:	2019	Make:	Nissan	Model:	Versa

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FRONT BUMPER	17	10	20	-	-	-	-	-	-	+18
2	AT HOOD	24	7	10	-	-	-	-	-	-	23
	Measurements recorded										
	☑ inches or ☐ mm										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

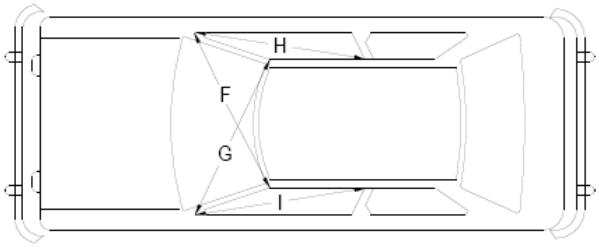
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

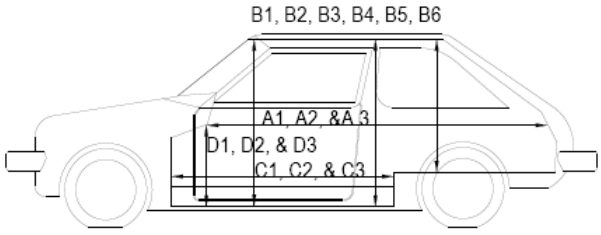
***Measure and document on the vehicle diagram the location of the maximum crush.

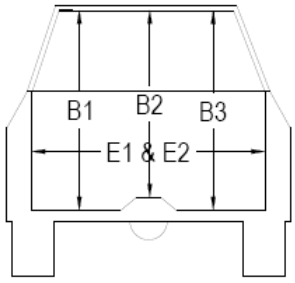
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure D.2. Exterior Crush Measurements for Test 690900-PVL-6.

Date:	2024-09-27	Test No.:	690900-PVL-6	VIN No.:	3N1CN7APOKL815309
Year:	2019	Make:	Nissan	Model:	Versa







OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

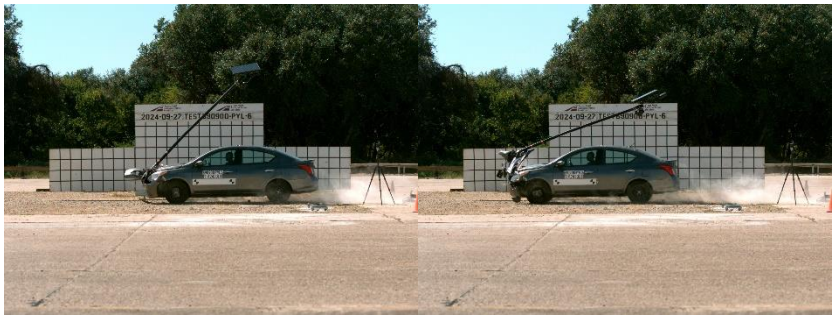
	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	40.50	0.00
B2	39.00	39.00	0.00
B3	40.50	40.50	0.00
B4	36.25	36.25	0.00
B5	36.00	36.00	0.00
B6	36.25	36.25	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

*Lateral area across the cab from driver's side kick panel to passenger's side kick panel.

Figure D.3. Occupant Compartment Measurements for Test 690900-PVL-6.

D.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.0500 s



(c) 0.1000 s (d) 0.1500 s

(e) 0.2000 s (f) 0.2500 s

(g) 0.3000 s (h) 0.3500 s

Figure D.4. Sequential Photographs for Test 690900-PVL-6 (Right Angle Views).

(a) 0.000 s (b) 0.0500 s

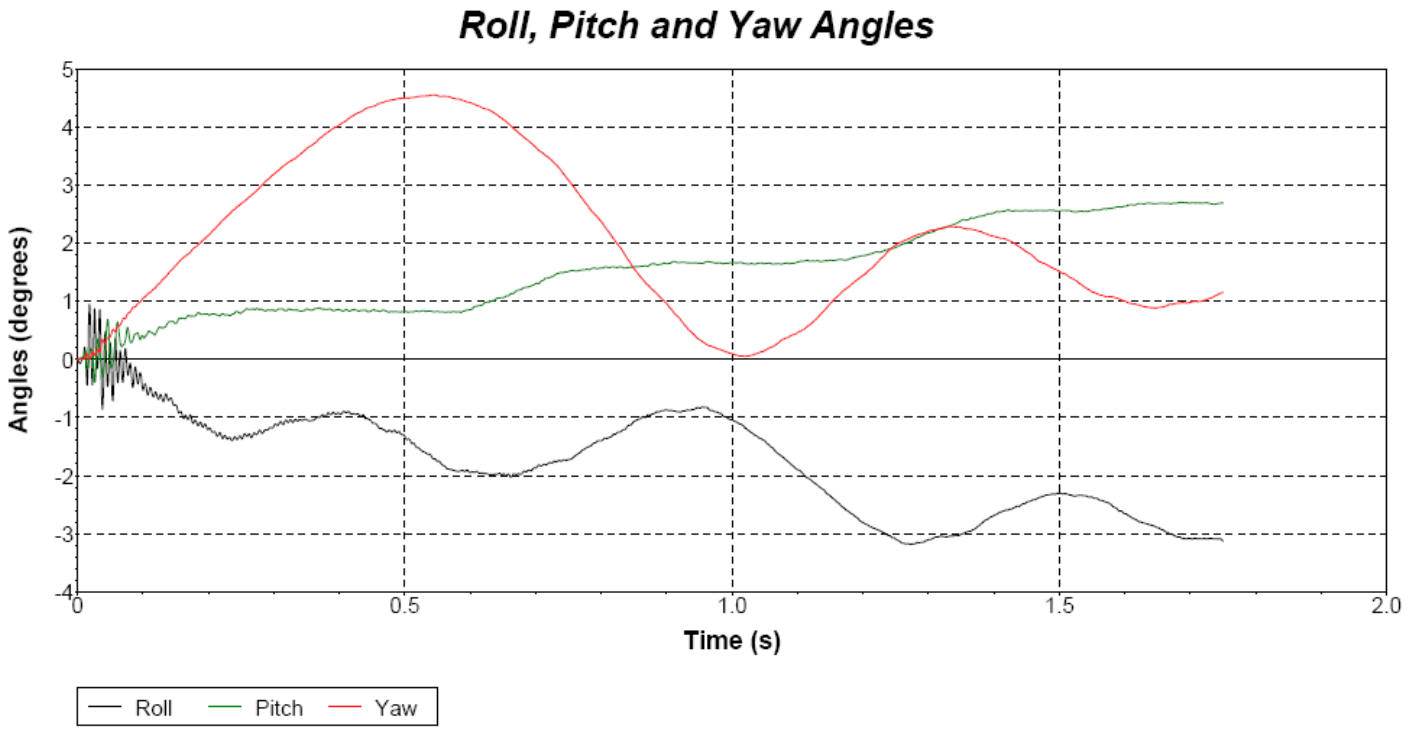
(c) 0.1000 s (d) 0.1500 s

(e) 0.2000 s (f) 0.2500 s

(g) 0.3000 s (h) 0.3500 s

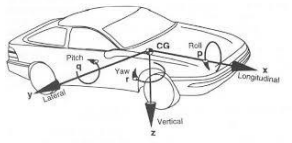
Figure D.5. Sequential Photographs for Test 690900-PVL-6 (Downstream Oblique Views).

D.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

4. Yaw.
5. Pitch.
6. Roll.



Test Number: 690900-PVL-6
Test Standard Test Number: *MASH* Test 3-61
Test Article: Breakaway Pole System
Test Vehicle: 2019 Nissan Versa
Inertial Mass: 2441 lbs
Gross Mass: 2606 lbs
Impact Speed: 62.3 mi/h
Impact Angle: 0°

Figure D.6. Vehicle Angular Displacements for Test 690900-PVL-6.

D.4. VEHICLE ACCELERATIONS

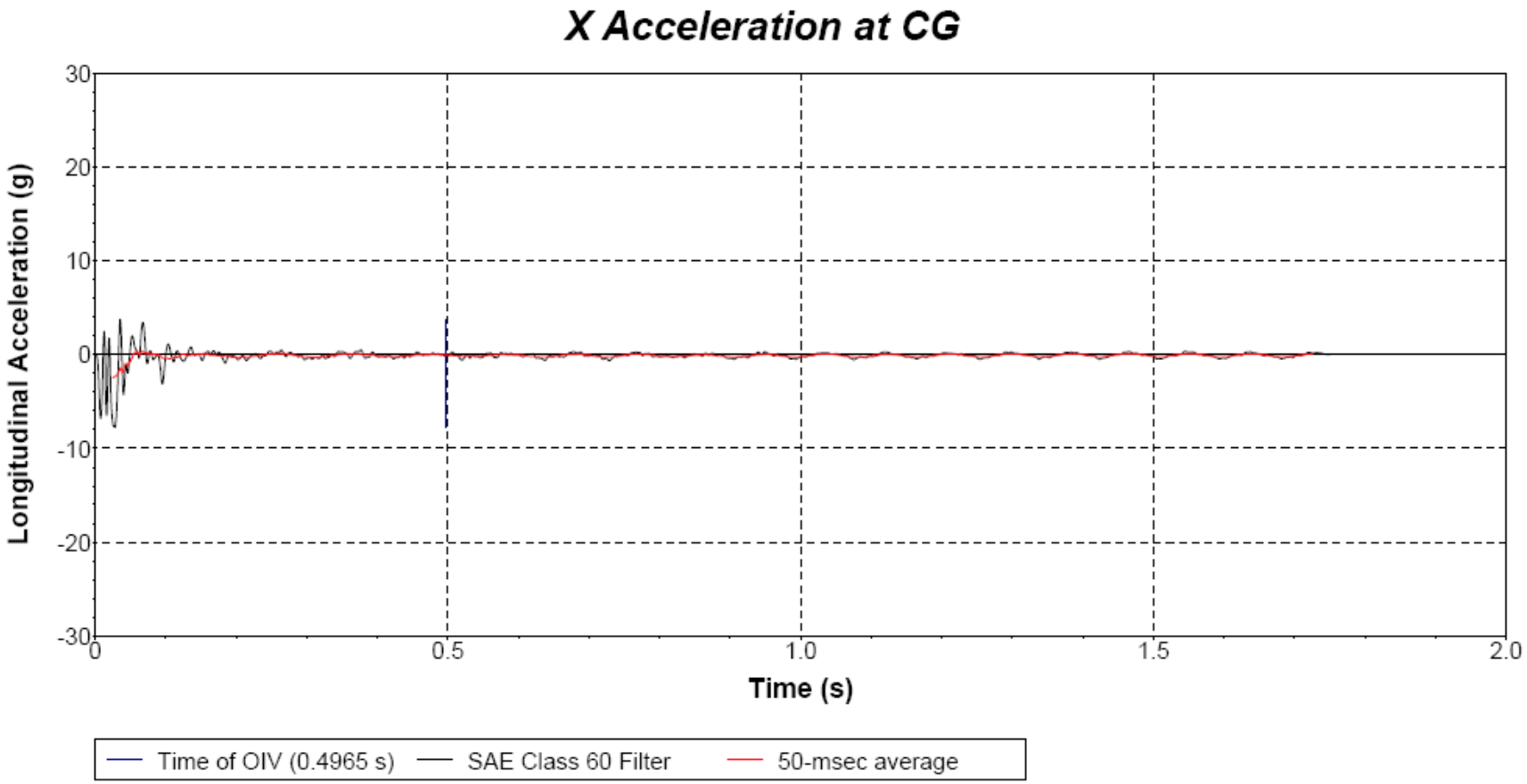


Figure D.7. Vehicle Longitudinal Accelerometer Trace for Test 690900-PVL-6 (Accelerometer Located at Center of Gravity).

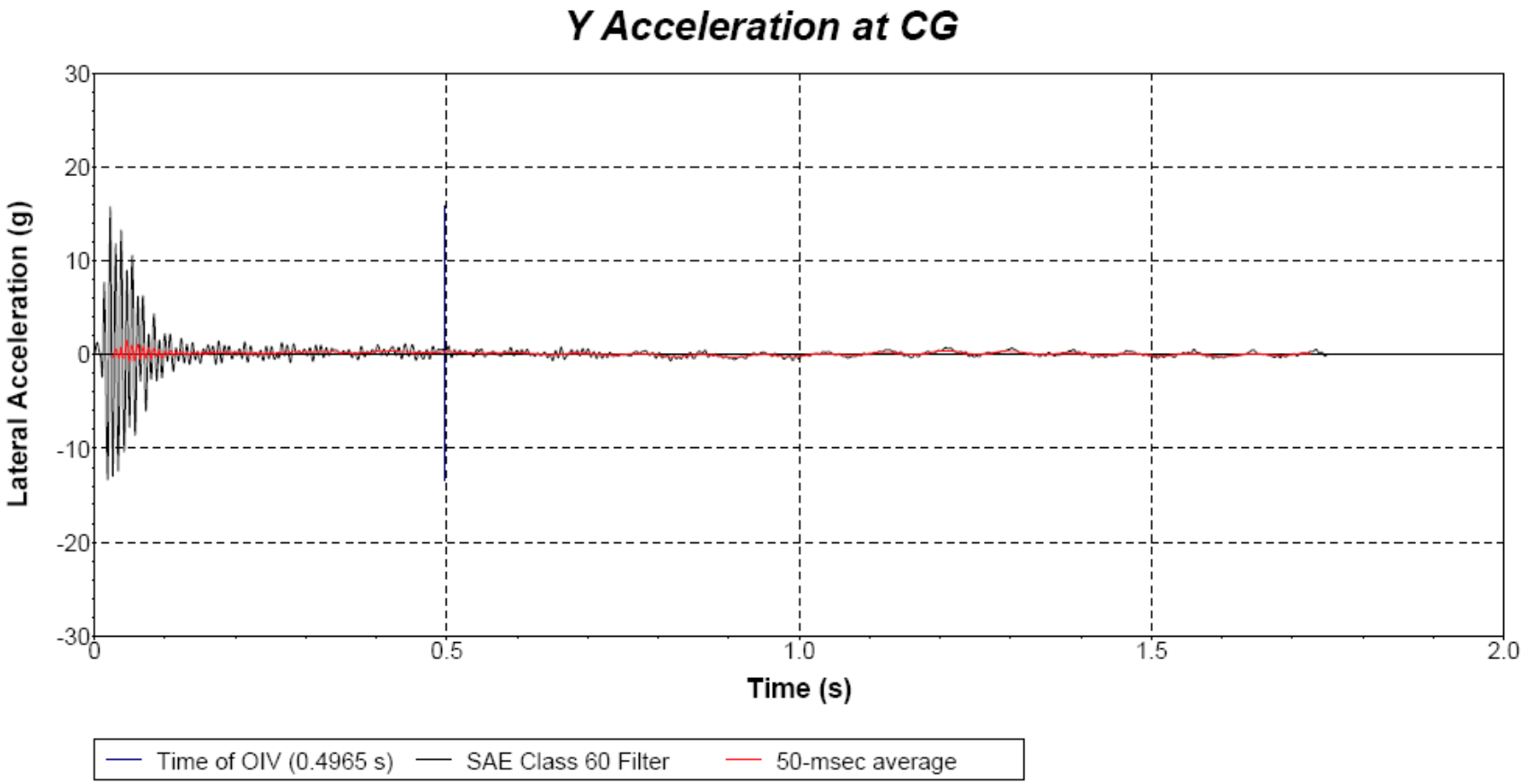


Figure D.8. Vehicle Lateral Accelerometer Trace for Test 690900-PVL-6 (Accelerometer Located at Center of Gravity).

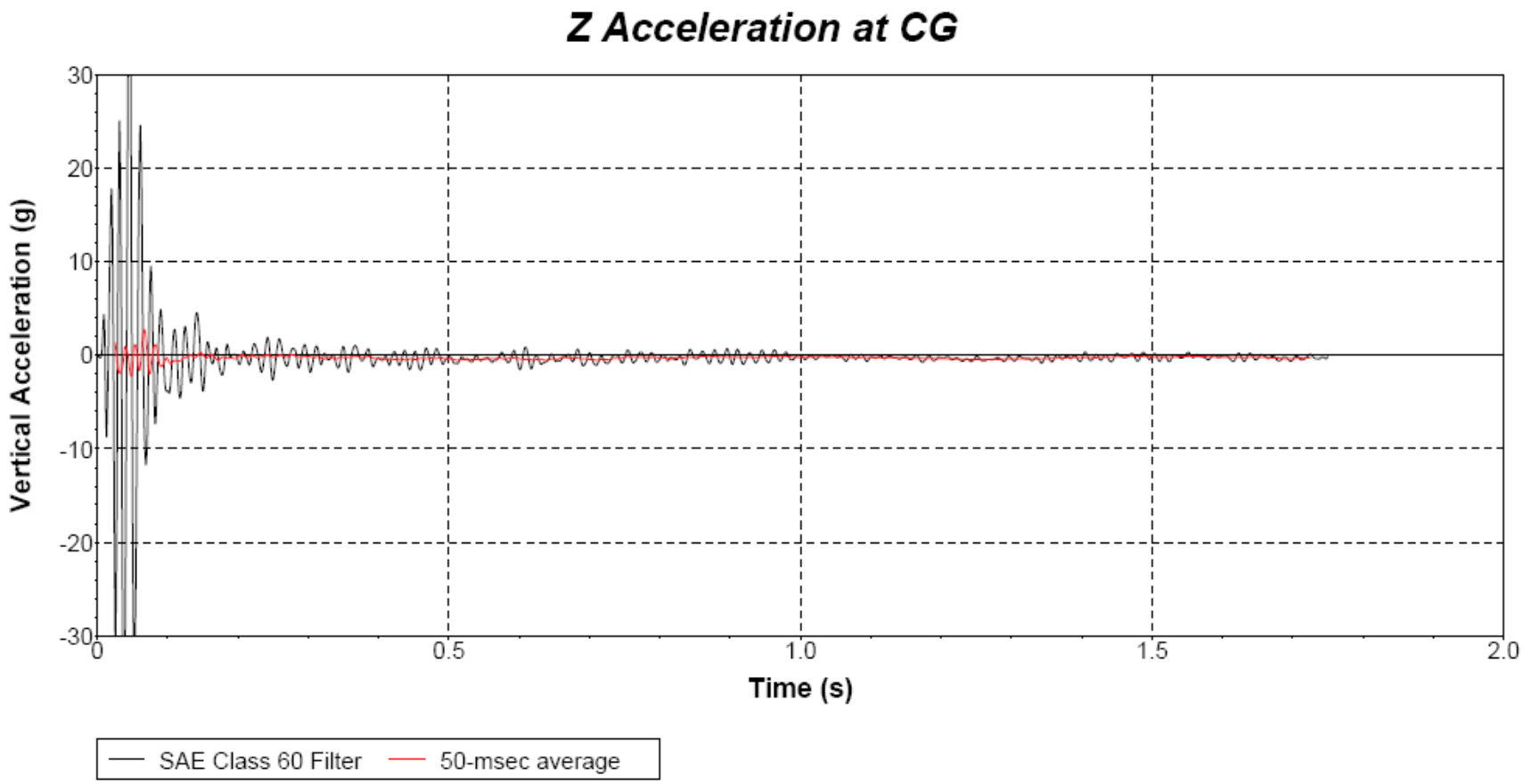


Figure D.9. Vehicle Vertical Accelerometer Trace for Test 690900-PVL-6 (Accelerometer Located at Center of Gravity).

APPENDIX E.

MASH TEST 3-62
(CRASH TEST 690900-PVL-7)

E.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-09-27 Test No.: 690900-PVL-7 VIN No.: 1C6RR6FT2JS188633

Year: 2018 Make: RAM Model: 1500

Tire Size: 265/70 R 17 Tire Inflation Pressure: 35 psi

Tread Type: Highway Odometer: 131964

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

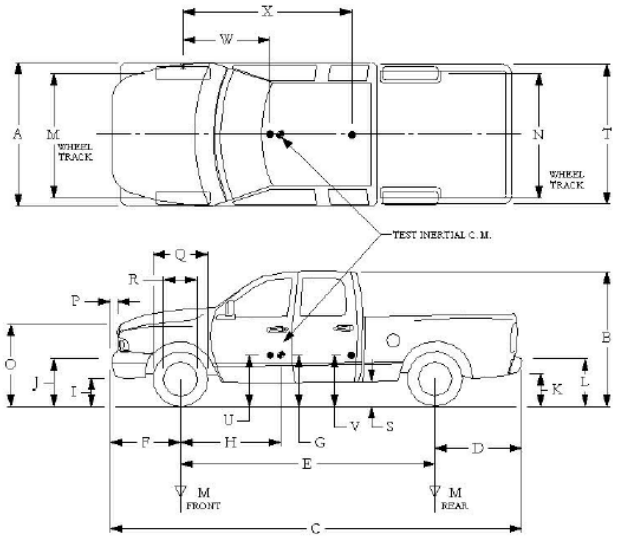
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

Transmission Type:
☑ Auto or ☐ Manual
☐ FWD ☑ RWD ☐ 4WD

Optional Equipment:
None

Dummy Data:
Type:
Mass:
Seat Position:



Geometry: inches

A	78.50	F	40.25	K	20.00	P	3.00	U	26.75
B	74.00	G	28.75	L	30.00	Q	30.50	V	30.25
C	229.00	H	62.10	M	68.50	R	18.00	W	62.00
D	48.25	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

Wheel Center Height Front	14.75	Wheel Well Clearance (Front)	6.00	Bottom Frame Height - Front	12.50
Wheel Center Height Rear	14.75	Wheel Well Clearance (Rear)	9.25	Bottom Frame Height - Rear	22.50

RANGE LIMIT: A=78 ±2 inches; C=237 ±13 inches; E=148 ±12 inches; F=39 ±3 inches; G = > 28 inches; H = 63 ±4 inches; O=43 ±4 inches; (M+N)/2=67 ±1.5 inches

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2913	2807	2807
Back	3900	M_{rear}	2072	2224	2224
Total	6700	M_{Total}	4985	5031	5031

(Allowable Range for TIM and GSM = 5000 lb ±110 lb)

Mass Distribution:
lb LF: 1407 RF: 1400 LR: 1111 RR: 1113

Figure E.1. Vehicle Properties for Test 690900-PVL-7.

Date: 2024-09-27 Test No.: 690900-PVL-7 VIN No.: 1C6RR6FT2JS188633

Year: 2018 Make: RAM Model: 1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FRONT BUMPER	19	8	20	-	-	-	-	-	-	-27
	Measurements recorded										
	☑ inches or ☐ mm										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

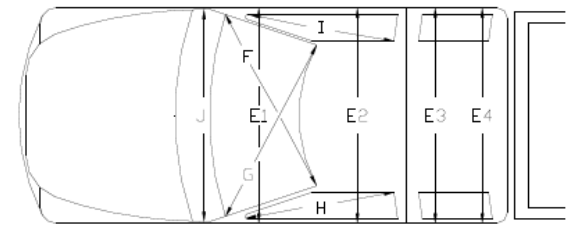
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

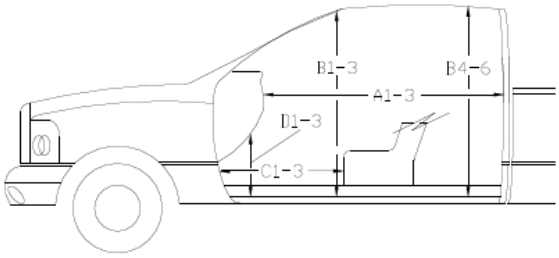
***Measure and document on the vehicle diagram the location of the maximum crush.

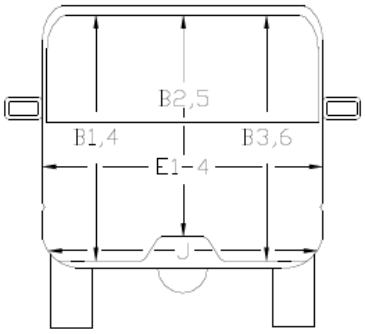
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure E.2. Exterior Crush Measurements for Test 690900-PVL-7.

Date:	2024-09-27	Test No.:	690900-PVL-7	VIN No.:	1C6RR6FT2JS188633
Year:	2018	Make:	RAM	Model:	1500







*Lateral area across the cab from driver's side kickpanel to passenger's side kickpanel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	65.00	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	42.25	-2.75
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure E.3. Occupant Compartment Measurements for Test 690900-PVL-7.

E.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.0500 s

(c) 0.1000 s (d) 0.1500 s

(e) 0.2000 s (f) 0.2500 s

(g) 0.3000 s (h) 0.3500 s

Figure E.4. Sequential Photographs for Test 690900-PVL-7 (Right Angle Views).

(a) 0.000 s (b) 0.0500 s

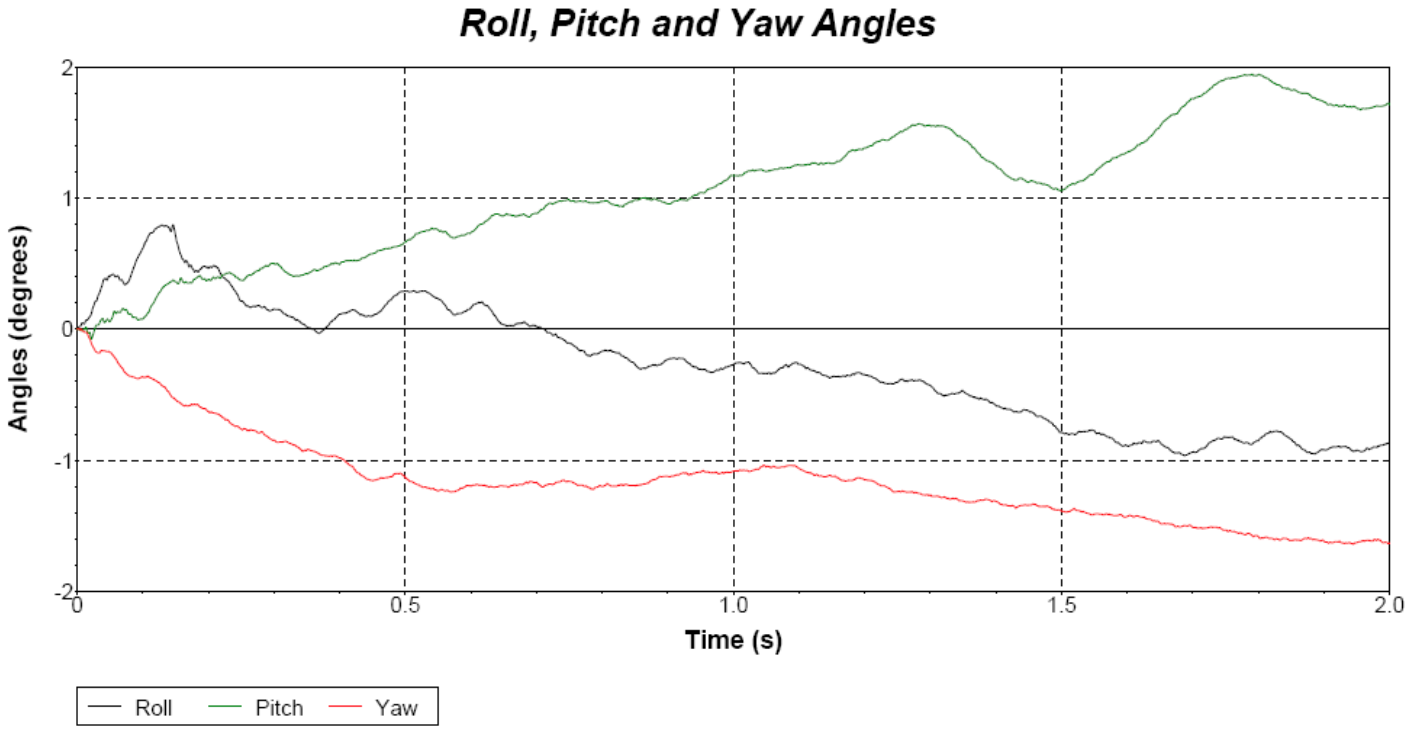
(c) 0.1000 s (d) 0.1500 s

(e) 0.2000 s (f) 0.2500 s

(g) 0.3000 s (h) 0.3500 s

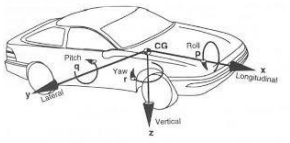
Figure E.5. Sequential Photographs for Test 690900-PVL-7 (Downstream Oblique Views).

E.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

7. Yaw.
8. Pitch.
9. Roll.



Test Number: 690900-PVL-7
Test Standard Test Number: *MASH* Test 3-62
Test Article: Breakaway Pole System
Test Vehicle: 2018 RAM 1500
Inertial Mass: 5031 lbs
Gross Mass: 5031 lbs
Impact Speed: 62.7 mi/h
Impact Angle: 0°

Figure E.6. Vehicle Angular Displacements for Test 690900-PVL-7.

E.4. VEHICLE ACCELERATIONS

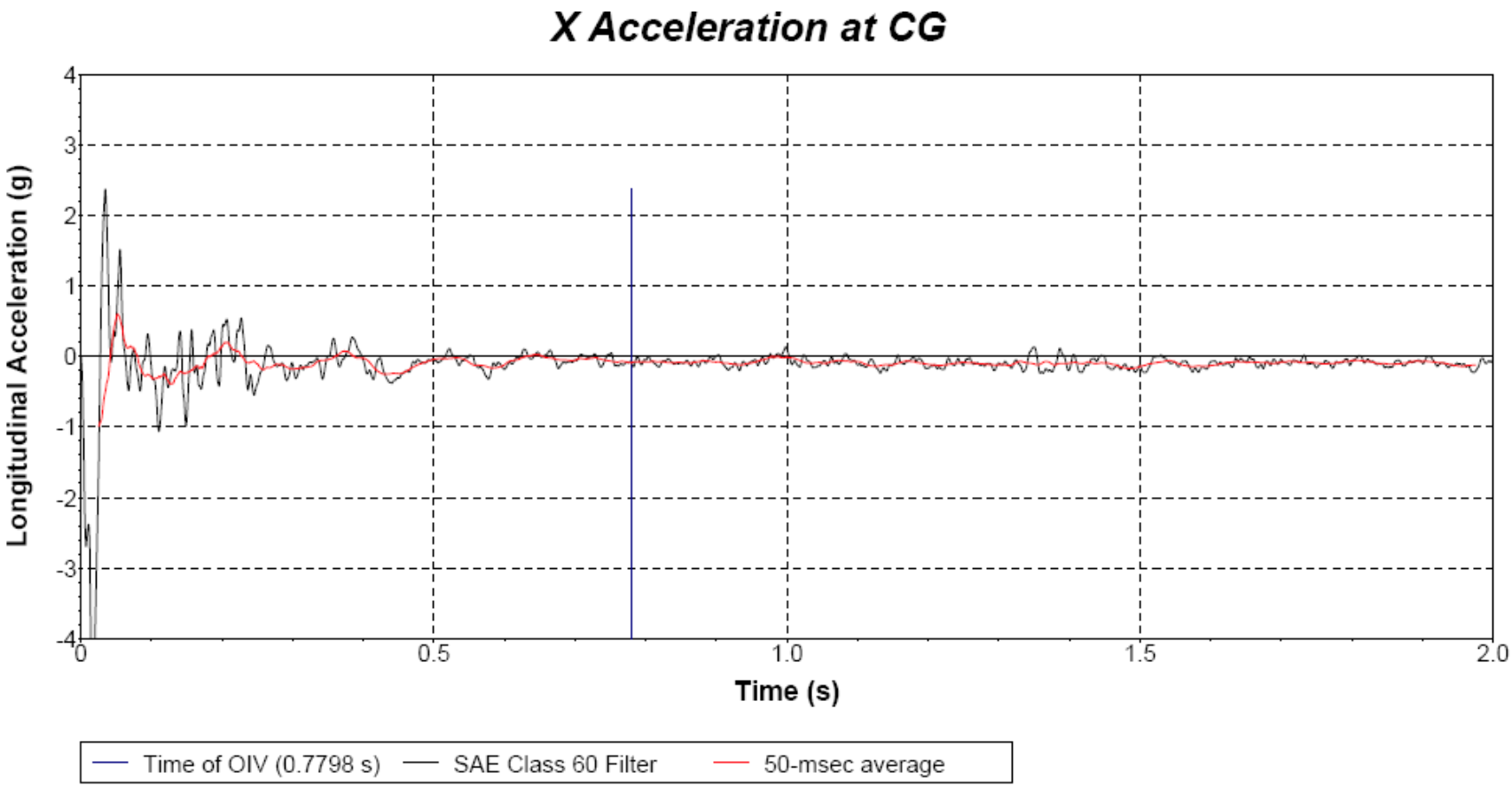


Figure E.7. Vehicle Longitudinal Accelerometer Trace for Test 690900-PVL-7 (Accelerometer Located at Center of Gravity).

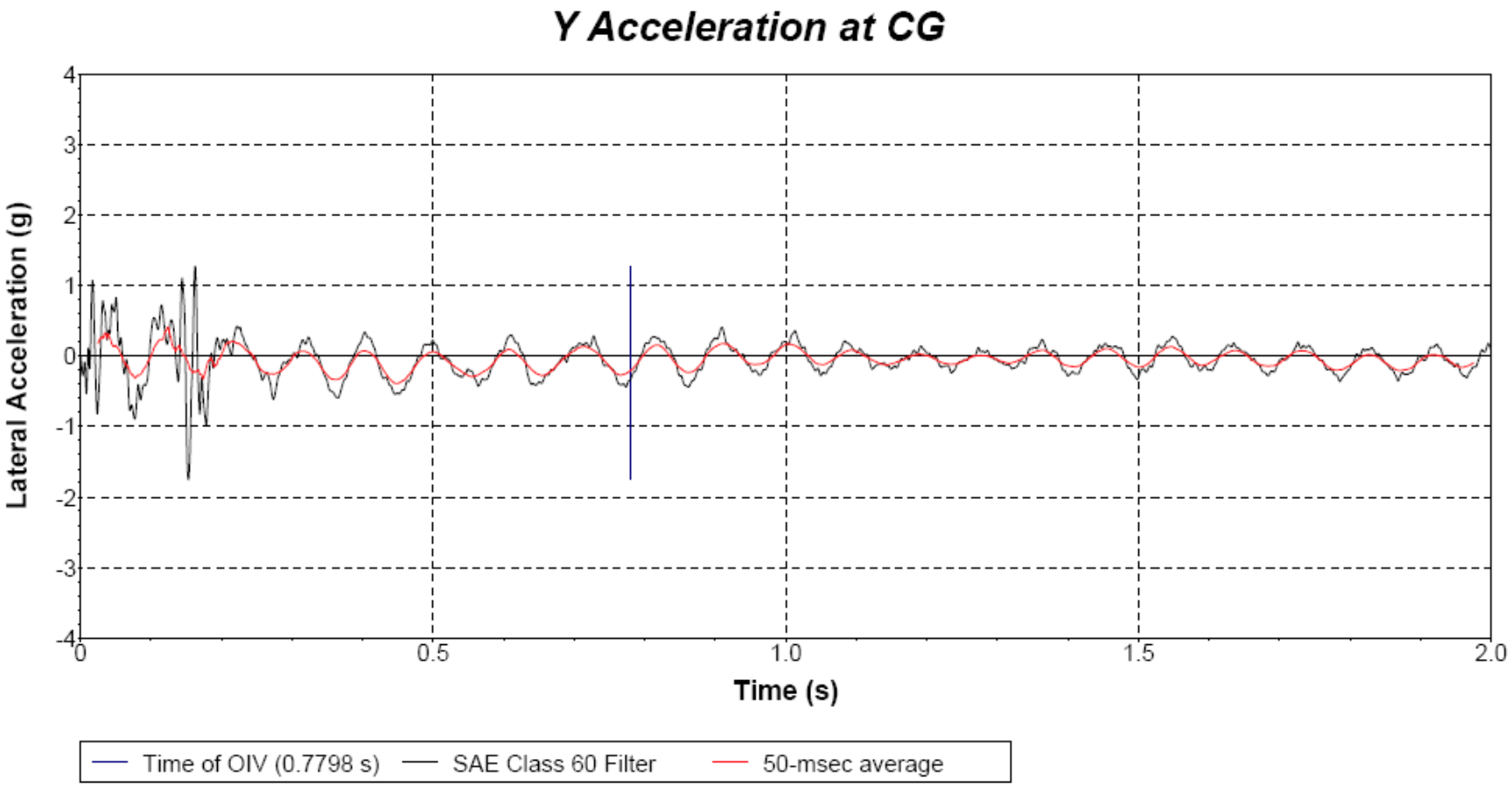


Figure E.8. Vehicle Lateral Accelerometer Trace for Test 690900-PVL-7 (Accelerometer Located at Center of Gravity).

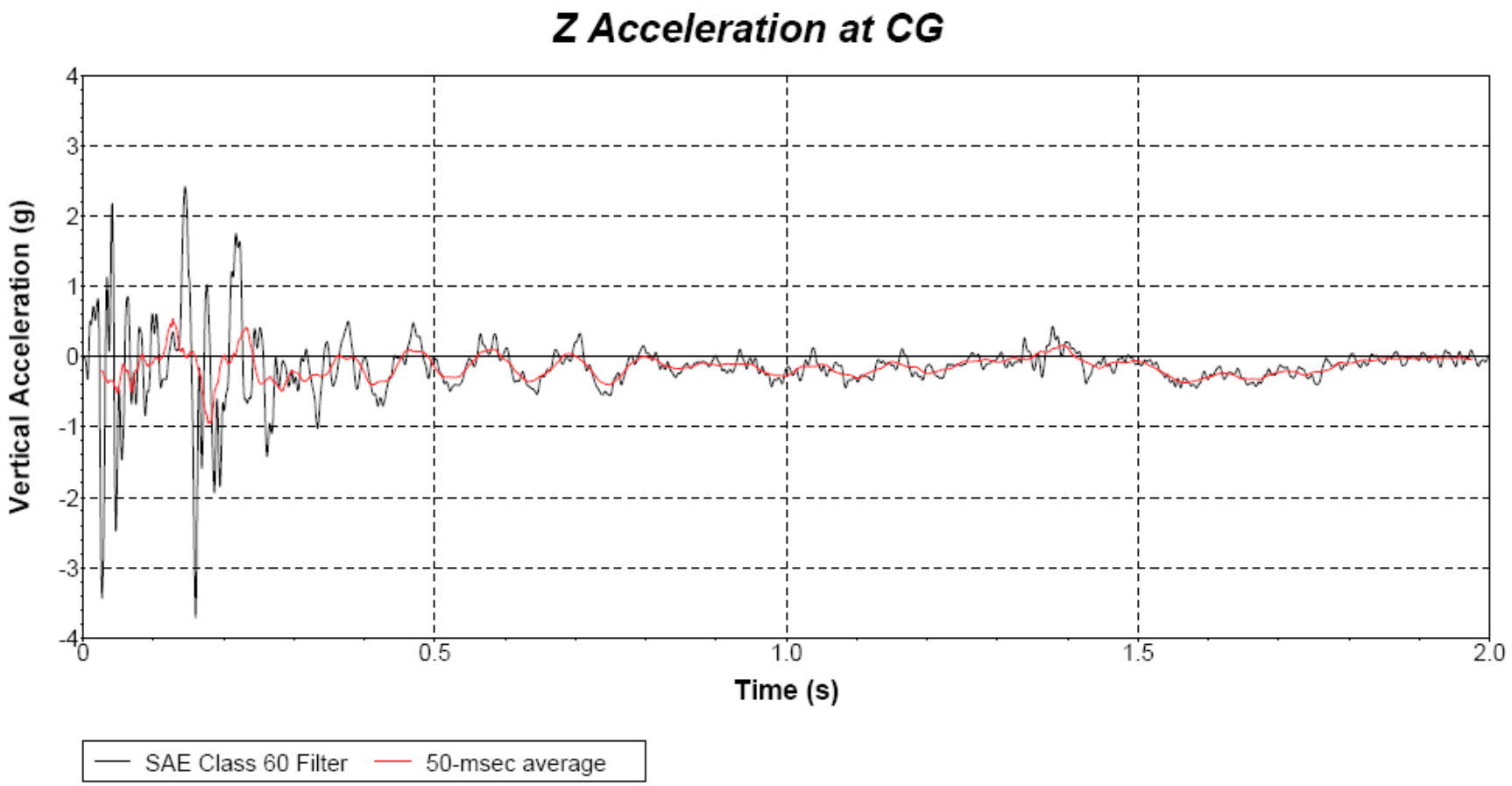


Figure E.9. Vehicle Vertical Accelerometer Trace for Test 690900-PVL-7 (Accelerometer Located at Center of Gravity).